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ABSTRACT

The many scientific activities and experiments performed during the Apollo 14 Mission are presented in a descriptive, non-technical format. Content relates to experiments on the lunar surface and to those performed while traveling in space, and provides a great deal of information about the flight. Many photographs from the journey, a map of the lunar walk, and a summary of highlights of manned space flights are included. (PR)

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Apollo 14: 1 Science at Fra Mauro

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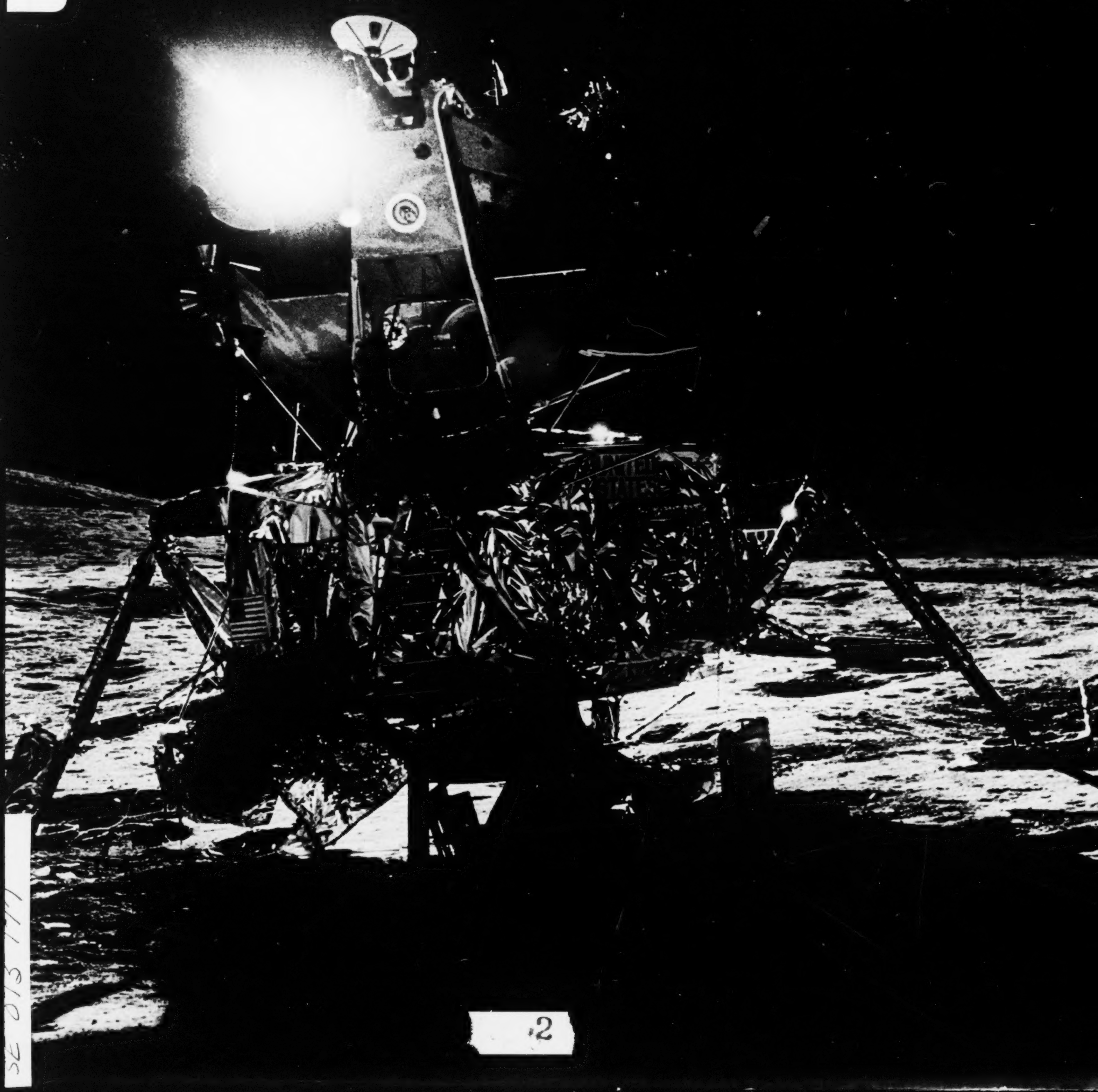

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Apollo 14: Science at Fra Mauro

By Walter Froehlich

F-NASA
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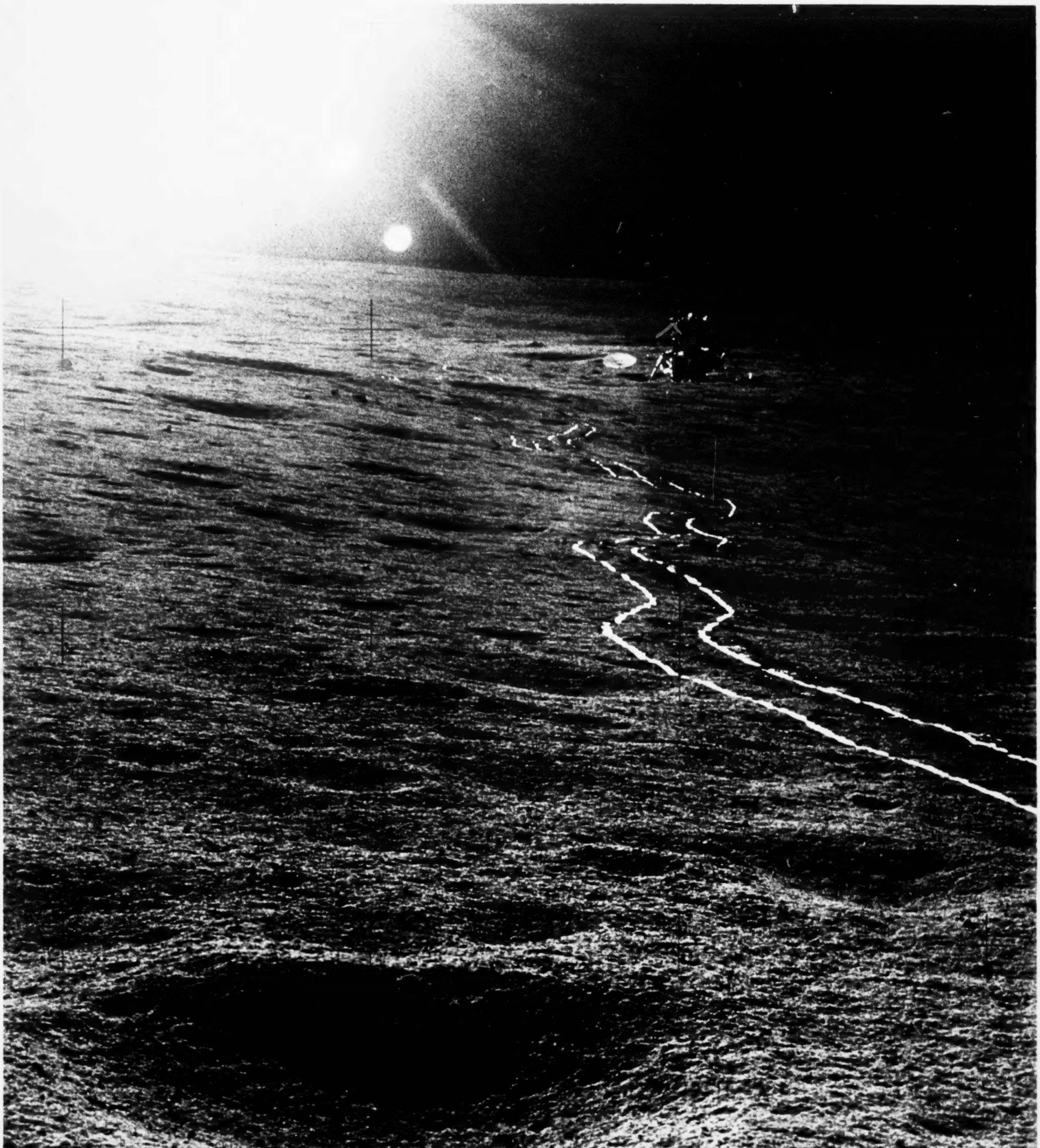
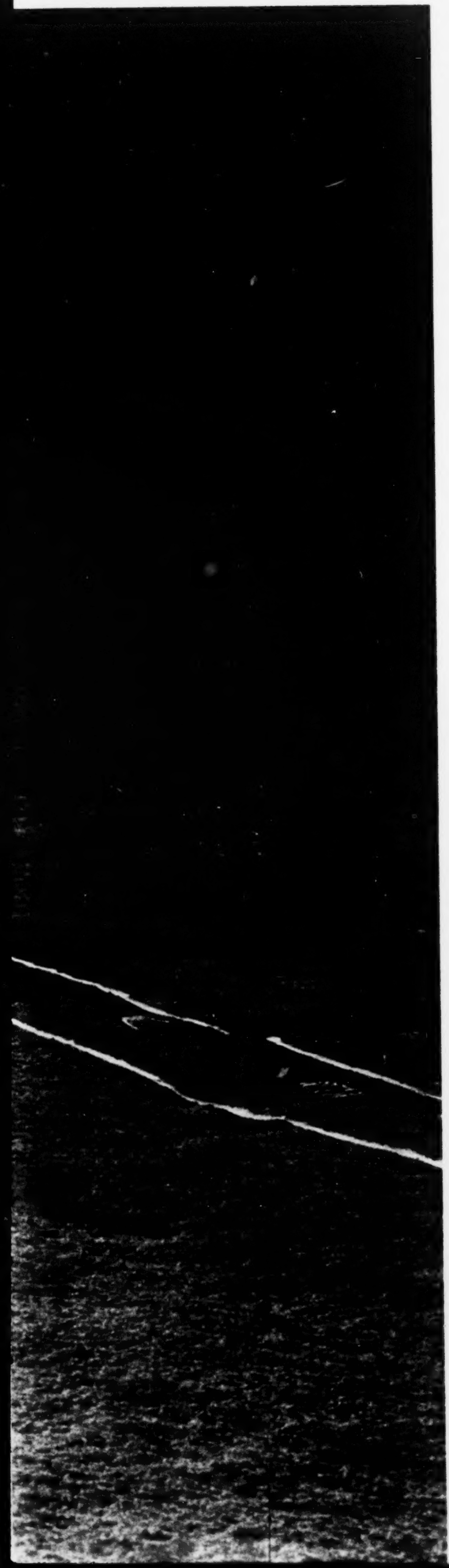
Tire tracks, drawn across the barren lunar surface, trace the path the astronauts walked with their two-wheel pull-cart from their landing craft, Antares, into the Fra Mauro foothills toward Doublet Crater.





It was the morning of a new day on the Moon. The Sun was hanging low in the sky, about 20 degrees above the horizon. Long, inky shadows contrasted sharply with the glaring brightness of lighted lunar surfaces where no atmosphere exists to refract the rays.

Astronauts Alan B. Shepard, Jr. and Edgar D. Mitchell were climbing a steepening slope; their maps indicated they were approaching their destination, the rim of Cone Crater where rocks may have remained unchanged since time began. Here might be found scientific treasures holding clues to the birth and development of the neighborhood of the universe of which the Earth is a part.

"You know we haven't reached the rim yet," said Apollo 14 Commander Shepard. "I'm not sure that was Flank (Crater) we were in a minute ago either," replied Astronaut Mitchell. "Wait a minute. The rim's right here . . . That's the east shoulder running down from Cone. That's Flank over there. We're going to hit it on the south side."

Pinpointing a major difficulty, Mitchell had earlier commented: "You can sure be deceived by slopes here. The Sun angle is very deceiving."

Walking on the Moon is easy because men and their backpacks weigh only one-sixth as much as they do on Earth. But uphill movement in a bulky space suit limits mobility and can be exhausting.

The rhythmic sounds of the astronauts' breathing was picked up by the built-in microphones of their helmets and could be heard a quarter of a million miles (400,000 kilometers) away at Mission Control in Houston, Texas. Also hearing it were millions of radio listeners and television viewers on every continent.

"Really got a pretty steep slope here," said Shepard.

"Yeah, we kind of figured that from listening to you," came a reply from Astronaut CAPCOM Fred W. Haise at Mission Control. (CAPCOM is the capsule communicator, an astronaut assigned to carry on the conversation between Mission Control and the Moon explorers.)

Another CAPCOM at Mission Control, Astronaut Ronald Evans, was talking with the third Apollo 14 crew member, Astronaut Stuart A. Roosa, flying in Moon orbit in "Kitty Hawk," the main Apollo spacecraft. He was waiting for Shepard and Mitchell to complete their Moon exploration and return to the Kitty Hawk.

Every so often, the men turned their heads back toward Antares, the lunar module moon landing craft or LM, to assure themselves it was still in their line of sight. It stood about one-half mile (800 meters) behind them at the bottom of the slope, parked on a slight incline. For Antares was their home and base station during their planned 33½ hour stay on the Moon. Antares would also serve as their launch pad and their spacecraft for the first lap of their return journey to Earth.

"I can stop and rest here for a minute," said Shepard.

"Okay, let me pull," answered Mitchell. He was referring to the two-wheeled pull-cart, the modularized equipment transporter or MET, especially designed for the Apollo 14 Moon expedition. The astronauts variously nicknamed the little aluminum vehicle "rickshaw," "wheelbarrow," and "caddy cart," and Shepard and Mitchell took turns pulling it. On it were geological tools, cameras and scientific instruments. Scientists had provided the men the best equipment modern technology could offer.

When Shepard and Mitchell reached the top of the ridge they thought to be Cone Crater, their disappointment was communicated to Mission Control and their television and radio audience.

The first hint of disillusionment came from Mitchell.

"Oh boy," he said as he got his first look above the ridge. "We got fooled on that one."

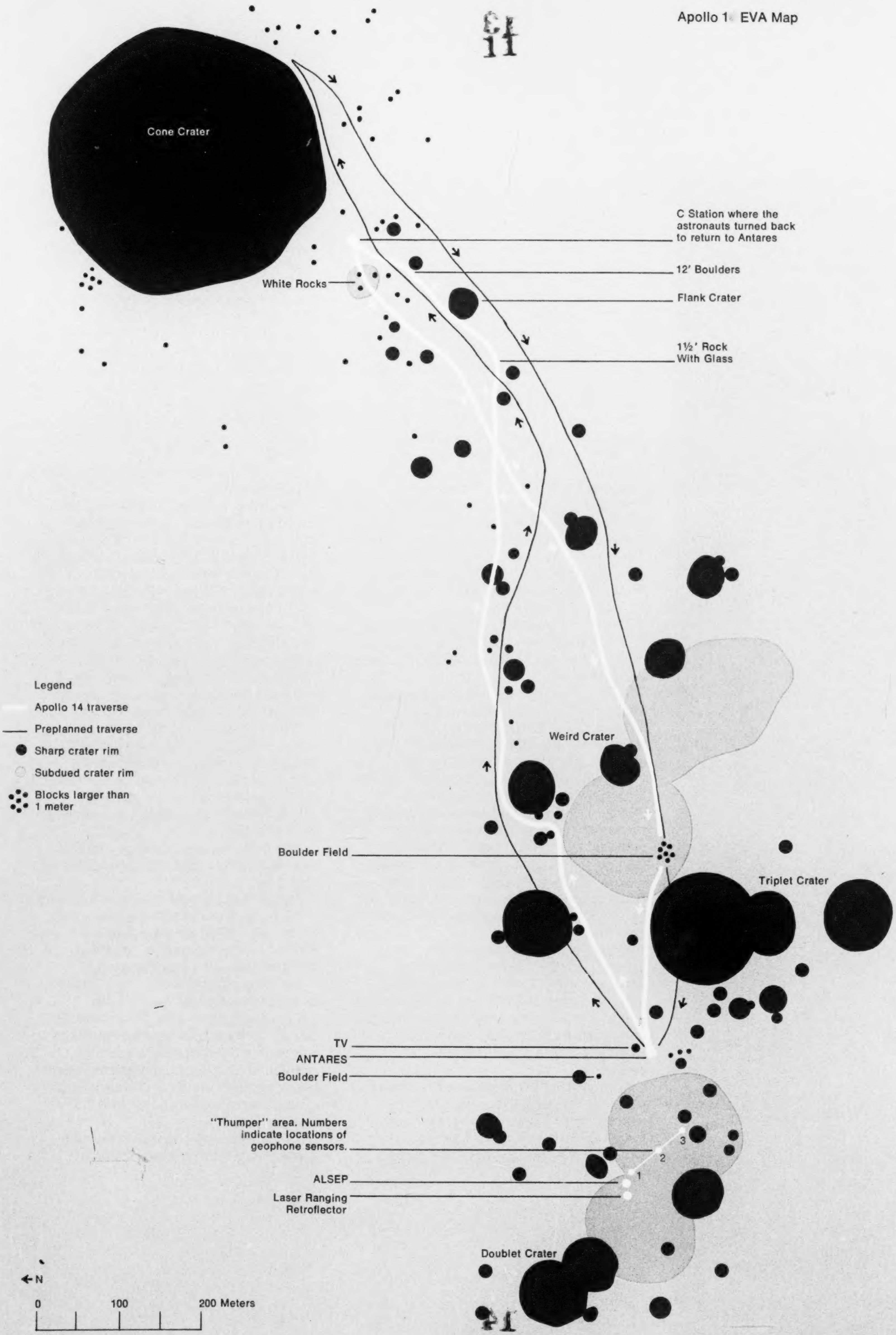
Shepard explained what had happened.

"Our positions are all in doubt now," he began. "What we were looking at was Flank . . . the top of it wasn't the rim of Cone. We've got a way to go yet."

On the crater-pocked lunar surface with its low gravitational pull, its unfamiliar lighting conditions, and its lack of conventional landmarks, maps are hard to interpret and directions difficult to follow, and the astronauts had underestimated the distance and difficulties of the terrain toward Cone Crater.

At a monitoring console at Mission Control, space physicians traced

Apollo 14 EVA Map


Cone Crater
C Station where the astronauts turned back to return to Antares
12' Boulders
White Rocks
Flank Crater
1½' Rock With Glass
Legend
Apollo 14 traverse
Preplanned traverse
Sharp crater rim
Subdued crater rim
Blocks larger than 1 meter
Weird Crater
Boulder Field
Triplet Crater
TV
ANTARES
Boulder Field
"Thumper" area. Numbers indicate locations of geophone sensors.
1
2
3
ALSEP
Laser Ranging Retroflector
Doublet Crater
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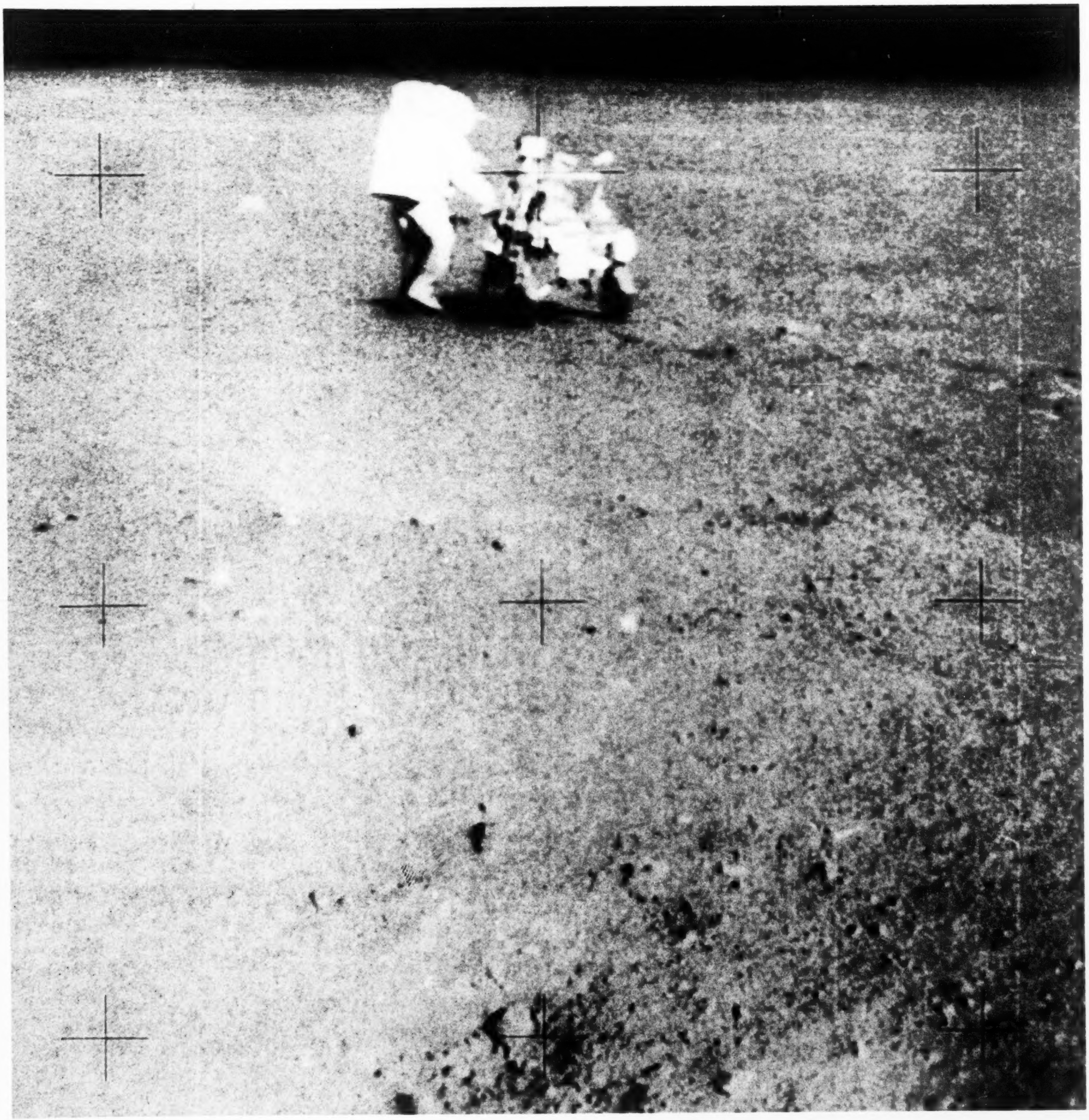
Unloading a hand tool. Astronaut Mitchell stops with the pull-cart, the "modularized equipment transporter" or MET, which was especially designed for Moon service with Apollo 14.



readings transmitted from tiny sensors attached to the astronauts' chests, and these readings indicated that Shepard's heart was beating 150 times a minute, Mitchell's 128 times.

CAPCOM Haise relayed a message from the physicians.

"Yeah, Al and Ed," he said, "They want you to take another stop here."

The human body consumes more oxygen and generates more heat as its activities increase. But the astronauts' portable life support system (PLSS) in their backpacks had only limited capacity for delivering oxygen and cooling the spacesuit. The astronauts' activities could not be allowed to exceed the PLSS's ability to support their needs. There was no danger of this happening now. Shepard's suit was set at a low cooling rate. But physicians do not want Moon-walking astronauts to overexert themselves.

More than two hours had elapsed since the men had opened Antares' hatch for that second Moon walk. According to the lunar traverse schedule, the time had come to think about turning around and heading back.

Keeping up with that schedule was vital if the men were to be able to complete several planned scientific experiments in the Cone Crater area and on the trek back toward Antares. Scientists felt that some of these experiments deserved priority over an all-out attempt to reach Cone Crater's rim, especially since rocks equally ancient could be retrieved in the area where the astronauts now were.

Far overhead, at an altitude of about 60 miles (97 kilometers) above the Moon, Astronaut Stuart A. Roosa was carrying on some other important experiments. He was photographing candidate landing sites for Apollo 16 and 17, to be launched in 1972. From the windows of Kitty Hawk he was taking pictures of the Descartes candidate site at which astronauts may stay longer, travel farther from the landing craft, set up equipment and carry out experiments even more complex than those of Apollo 14.

These future flights will bring a battery-powered, jeep-like Rover to the Moon for astronauts to drive over larger areas, and transport heavier equipment and more massive quantities of Moon rocks than their predecessors.

Roosa, too, was aiming radar beams to Earth and a set of identical beams at the Moon so that scientists on Earth could compare the Moon-aimed beams, after they were reflected by the Moon and bounced to Earth, with those aimed directly at Earth. From the comparisons, scientists hoped to learn much about the Moon's surface properties, and also about layers below the surface. The experiment was called "Bistatic Radar."

Roosa also aimed radio signals at the Moon to determine more accurately the contours and heights of lunar mountains and hills.

That experiment with an "S-Band transponder" requires analysis of reflected radio beams which also give clues to variations in lunar gravity. These variations are believed to be caused by mass concentrations, called "mascons," of certain materials below the Moon's surface.

Even while Roosa was engaged in charting the Moon, his colleagues on the lunar surface were illustrating the importance to astronauts of accurate and complete maps of the regions near landing sites.

Cone Crater, by the best estimates the astronauts could make from their maps, was still a good 30-minute walk and this day they had learned that their own best estimates relating to Moon distances were not particularly reliable.

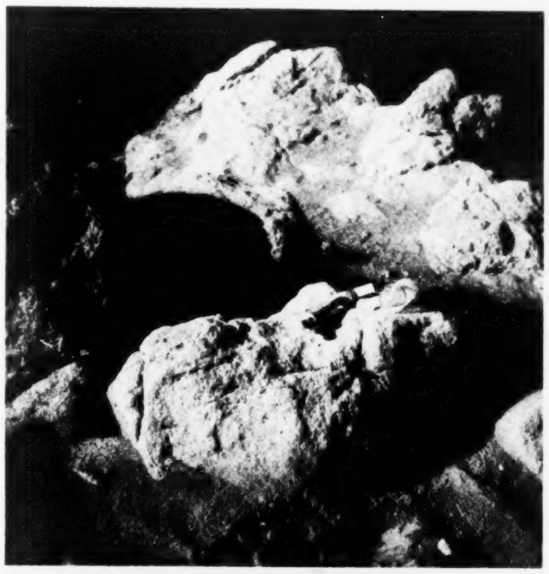
"I don't think we'll have time to go up there," said Shepard. Even at Moon distance, listeners on Earth could sense a tone of sadness and reluctance in his voice.

"Oh, let's give it a whirl," pleaded Mitchell. "Gee whiz. We can't stop without looking into Cone Crater."

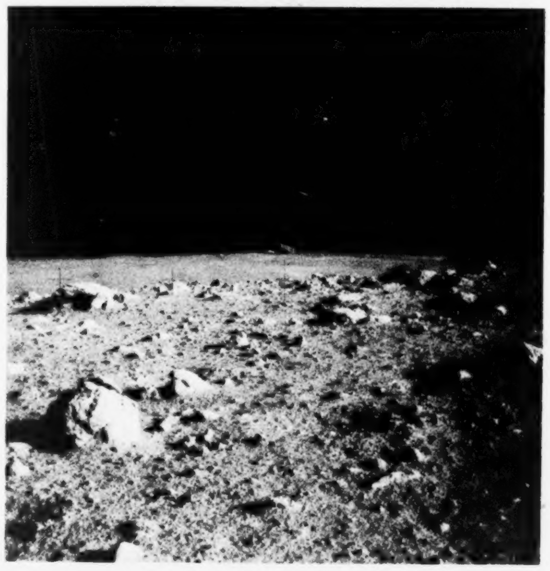
Shepard was not yet convinced. "I think we'll waste an awful lot of time traveling and not do much documenting," he said.

The word documenting was a reference to photographing and describing rocks and their location before and after picking them up for examination by scientists on Earth. This was one of the major tasks scientists hoped the astronauts would accomplish in the Cone Crater area and at various prescribed locations on their return walk to Antares.

CAPCOM Haise interrupted the Moon walkers' discussion. "Okay, Al

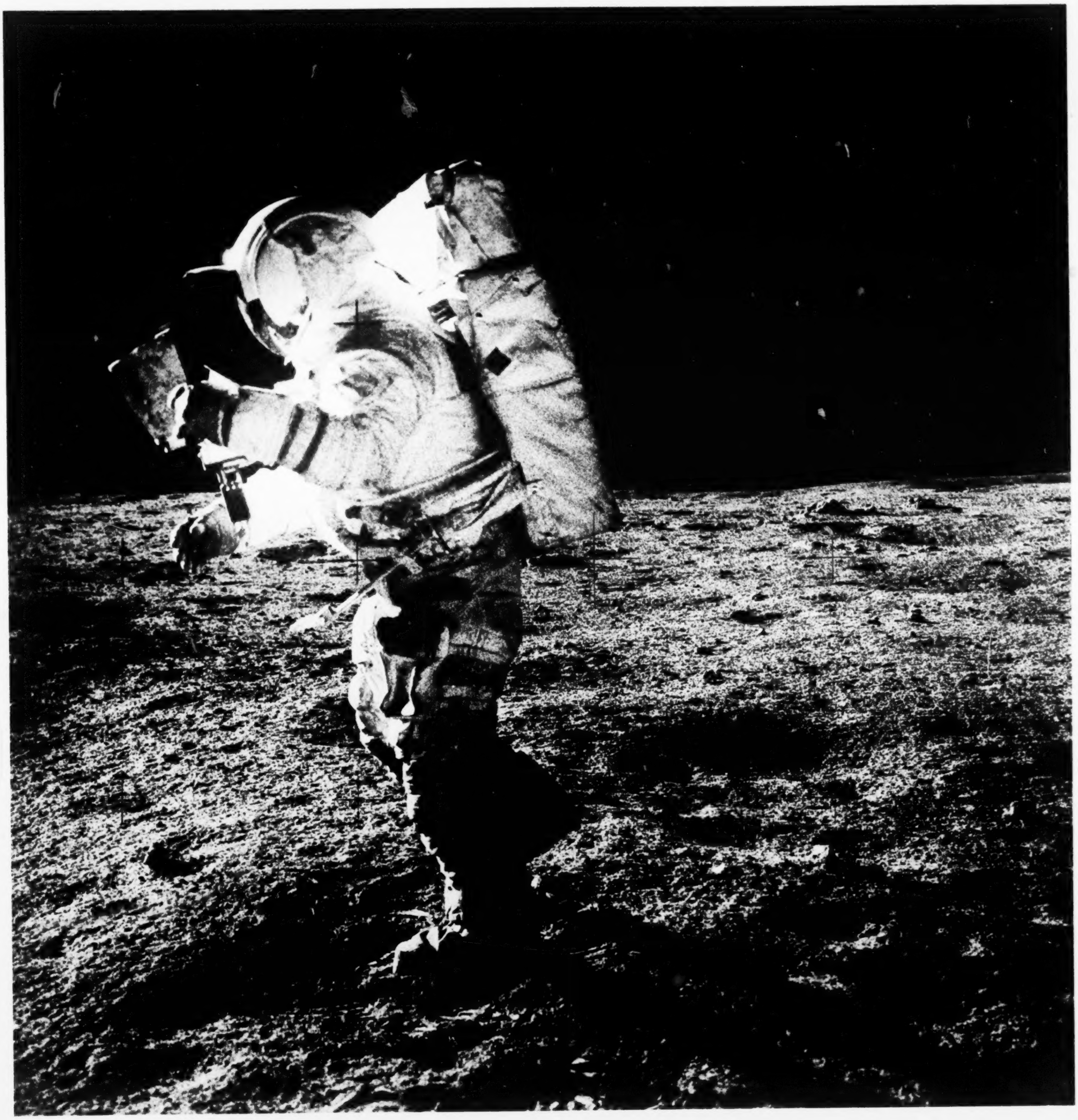


Hammer and small rock collection bag, placed atop these lunar boulders by Apollo 14 astronauts, provide perspective for assessing the boulders' size.



Untouched by man or any other form of life until Apollo 14 arrived, this once obscure region in the universe will now be known as the site of man's third Moon landing.

His heavy boots scuffing the soft grayish-brown lunar dust, Astronaut Mitchell checks the map as he moves across a forbidding Moonscape. Some dust can be seen clinging to legs of Moon suit.



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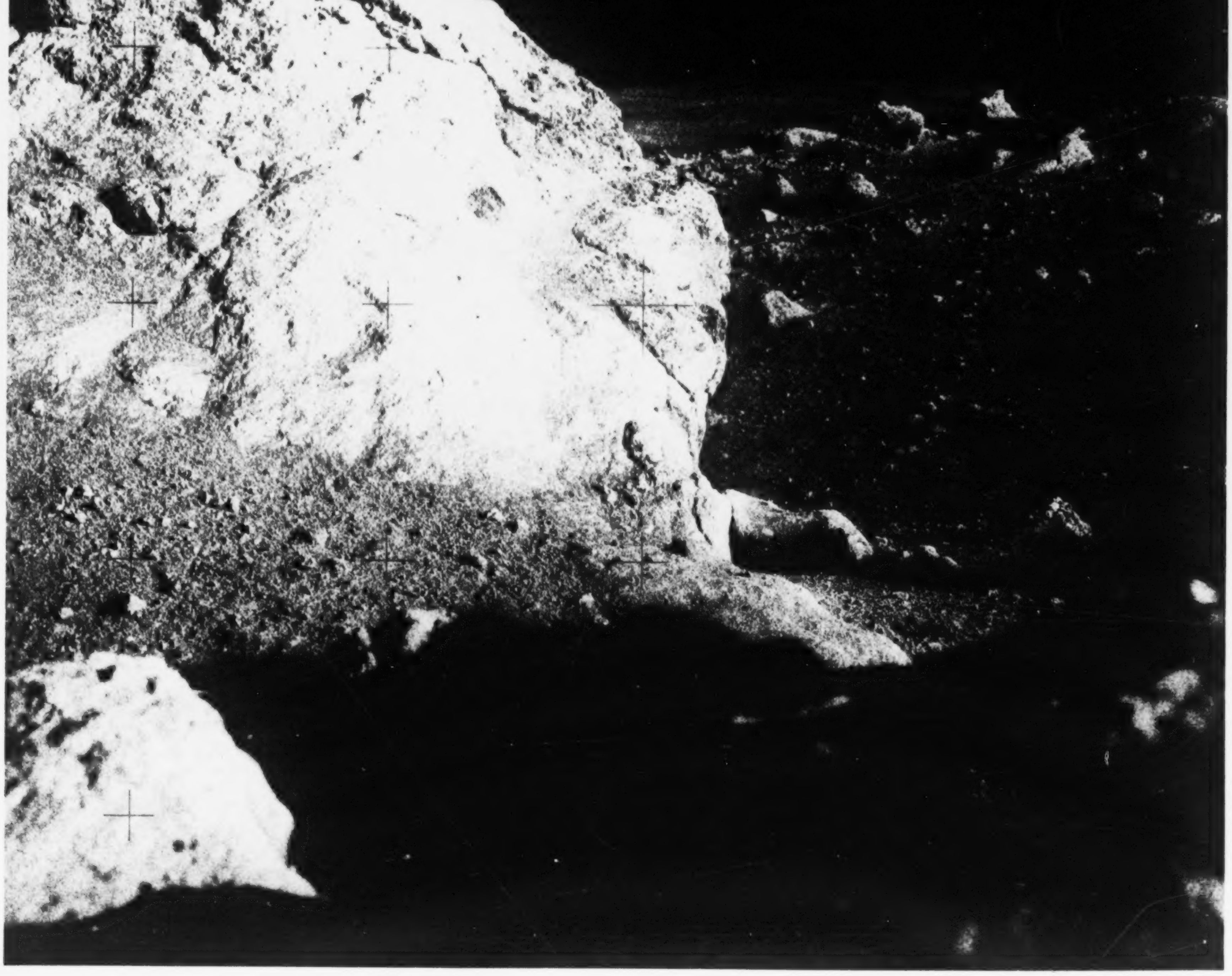
From samples chipped from rocks like this by Apollo 14 astronauts, scientists will attempt to trace the history of the solar system.



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and Ed," said Haise. "In view of your estimate of where your location is and how long it's going to take to get to Cone, the word from the backroom is they'd like you to consider where you are as the edge of Cone Crater."

Mission Control was asking the astronauts to relinquish their hopes for scaling Cone rim.

Shepard was ready to concur and said so to his companion.

"I think what we re looking at right here, this boulder field, Ed, is the stuff that's ejected from Cone."

The ancient materials they sought at Cone Crater were pieces of the Moon's interior gouged out from miles below the Sea of Rains, when a meteroid struck it millions of years ago. Shepard knew that this material must have been catapulted to the area in which he was standing now.

Mission Control suggested the men might leave the MET behind them to speed their progress, but the astronauts said they would not like to be without the tools carried on the MET.

"Well, we're three-quarters there," Mitchell commented.

"Okay," said Shepard, "We'll press on a little farther. Houston, keep your eye on the time."

He wanted Mission Control to keep him posted frequently on how much longer he and Mitchell could safely stay outside the LM before their oxygen supply and other life support essentials would reach critical quantities. But Mission Control called back that he and Mitchell could have an extension of 30 minutes of Moon walk time beyond the four hours and 15 minutes originally allotted.

Shepard became more cheerful.

"I want to tell you, it's a fantastic view from here," he said. "We're approaching the edge of the rugged boulder field to the west rim. It appears as though the best for us to do will be to go to the west rim and document it from there even though the Sun angle may not be quite as good. Well, we're pushing out in that direction."

"Roger, Al," the CAPCOM acknowledged, "You're moving to the west then."

Again Mission Control suggested abandoning the MET at least until the men returned from Cone's rim, but Mitchell explained "It's not that hard with the MET, we need these tools." Shepard concurred. "No, the MET's not slowing us down, Houston. It's just a question of time. We'll get there."

They didn't. As they threaded their way through the forest of boulders collecting rock samples and dictating their observations to Houston, the 30 minutes of extended Moon walk time soon evaporated.

Surrounded by automobile-size boulders taller than they—some 10 to 12 feet (three to 3.6 meters) in height—Shepard and Mitchell stopped. They had arrived at a point at which Mitchell was to measure the Moon's magnetic field. From the portable magnetometer on the MET, Mitchell pulled a 50-foot (15 meter) cable to which was attached a sensor. He positioned the sensor above the site selected for measurement and as he had done once before during the trek, read off the delicate instrument's dial displays.

Physicians at Mission Control noted that the rate of Shepard's heart beat had slowed to 108 per minute and Mitchell's to 86. The difference was due mostly to Shepard's harder work with scoops and tongs for gathering rocks while Mitchell was restowing the magnetometer sensor. Shepard carefully deposited his samples in numbered plastic bags so that scientists would later know the exact location and the circumstances of selection for each of the rocks.

"All right," Shepard began one of his typical geological descriptions. "I would say, Houston, that most of these boulders are the same brownish grey that we've found, but we see one that is definitely almost white in color, a very definite difference in color which we'll document. We noted this beneath this dark brownish regolith (mantlerock overlying solid rock layers), there is a very light brown layer and I think we'll get a core tube right here to show that. As a matter of fact, I think I'll do that right now."

Shepard met resistance, perhaps rock or compacted soil, as he sank the core tube into the ground. The material proved to be so granular that most of it fell out of the tube. Astronauts are trained to be talkative during such explorations because scientists want to have complete descriptions of how samples were collected. Shepard dutifully continued his

His long, dark shadow silhouetted against the lunar surface, Apollo 14 commander Shepard took this photograph of Fra Mauro boulder field. Note geological tools atop center rock.

Looking at one of the countless craters ahead of him, Mitchell surveys the desolation of a typical lunar scene. Backpack contains oxygen for breathing and water for the space suit's temperature control system.

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Using pull-cart as a mobile work bench, Mitchell adjusts portable magnetometer. With a sensor attached to the instrument by a 50-foot (15-meter) cable, he measured the Moon's magnetic field.

commentary.

"Now I'm sampling a layer that is sort of light gray just under the regolith with bag number nine, and bag number ten with a sample of some of the surface rocks that were right around that area."

Finally, the CAPCOM broke into the astronauts' busy chatter. "To get us back on the old timeline (schedule) here, when you depart C (their station at the time) we'd like you to proceed directly to F, Weird (a point near Weird Crater so designated on the astronauts' Moon map during preparations for the flight) . . . En route you can make grab samples as you see fit."

"Grab samples" are randomly selected without attempts at complete documentation.

The men were now on their way back to Antares.

Frequently, scientists at Mission Control asked questions of the astronauts which were transmitted to them through the CAPCOM. Once the scientists wanted to know whether Shepard noticed any dust on top of the rocks. Another time, they asked him to compare the various boulders. The astronauts had been given geology training for just such purposes.

This kind of "team exploration" by astronauts on the Moon and scientists on Earth has become standard procedure in manned Moon landing missions. Shepard and Mitchell worked their way past Weird Crater. East of Triplet Crater Shepard dug a small trench.

"I'm doing trenching. It's going fairly easily, but I need the extension handle (of the trenching tool, which is essentially a small shovel) to get deeper, to edge through that. I'm cutting into a rim of a crater which is approximately, oh, say six meters (20 feet) in diameter."

The CAPCOM relayed a question by the scientists.

"How deep did you get down?"

Shepard explained. "Well, the trench is about a foot and a half deep. I gave up actually not because it was hard digging, but because the walls kept falling in on it."

They passed through another boulder field and then past North Crater back to Antares.

The astronauts were coming back into the field of view of the color television camera they had set up near Antares and TV viewers throughout the world could see them move on the lunar surface much like two wiggling man-shaped white blobs. Even with color transmission, the Moon pictures were more a contrast between the darkness of the sky, the Sun-drenched lunar surface, the reflective astronaut suits and stark shadows.

Though the astronauts carried out their tasks in businesslike, earnest fashion, there emerged sporadic incidents of humor as, for example, when the men accidentally knocked the TV camera over.

As Shepard was turning it upright again, he wondered whether the camera was put out of commission.

"Fred," he said to CAPCOM Haise, "We're going to have a real practical problem here—probably be able to see what the lunar dust does to a camera lens. Do you see anything at all?"

Haise looked at the large TV screen on the front wall of the Mission Control room, then assured Shepard. "Yeah," he said, "I think it's a better picture. Lunar dust helps the TV picture, I guess."

Shepard could not suppress a hearty laugh. "Okay," he said. "We'll see to it that a little TV lens will get dusted in the future."

But Shepard took no chance of leaving the most surprising and humorous episode of the mission to coincidence. Just before reentering Antares, Shepard removed golf balls from his Moon suit. Using the detached handle from one of the geological implements he swung—and missed. To make sure historians would never doubt who was the first golfer on the Moon, Shepard took two more one-hand swings. (The bulky Moon suit prevented Shepard from placing his arms close enough together to grip the handle with both hands.) He sent the balls soaring above the Moon's surface where no atmosphere exists and there is little gravitational attraction to slow them.

"There it goes," he gloated, "miles and miles and miles."

Later, on the return flight toward Earth, he estimated that the first ball was propelled 200 yards (180 meters), and the second 400 yards (360 meters).

Mitchell climbed first into Antares and Shepard handed him the 51 pounds (23 kilograms) of collected Moon rocks and soil. Among them were the largest Moon pieces ever brought to Earth. Some were

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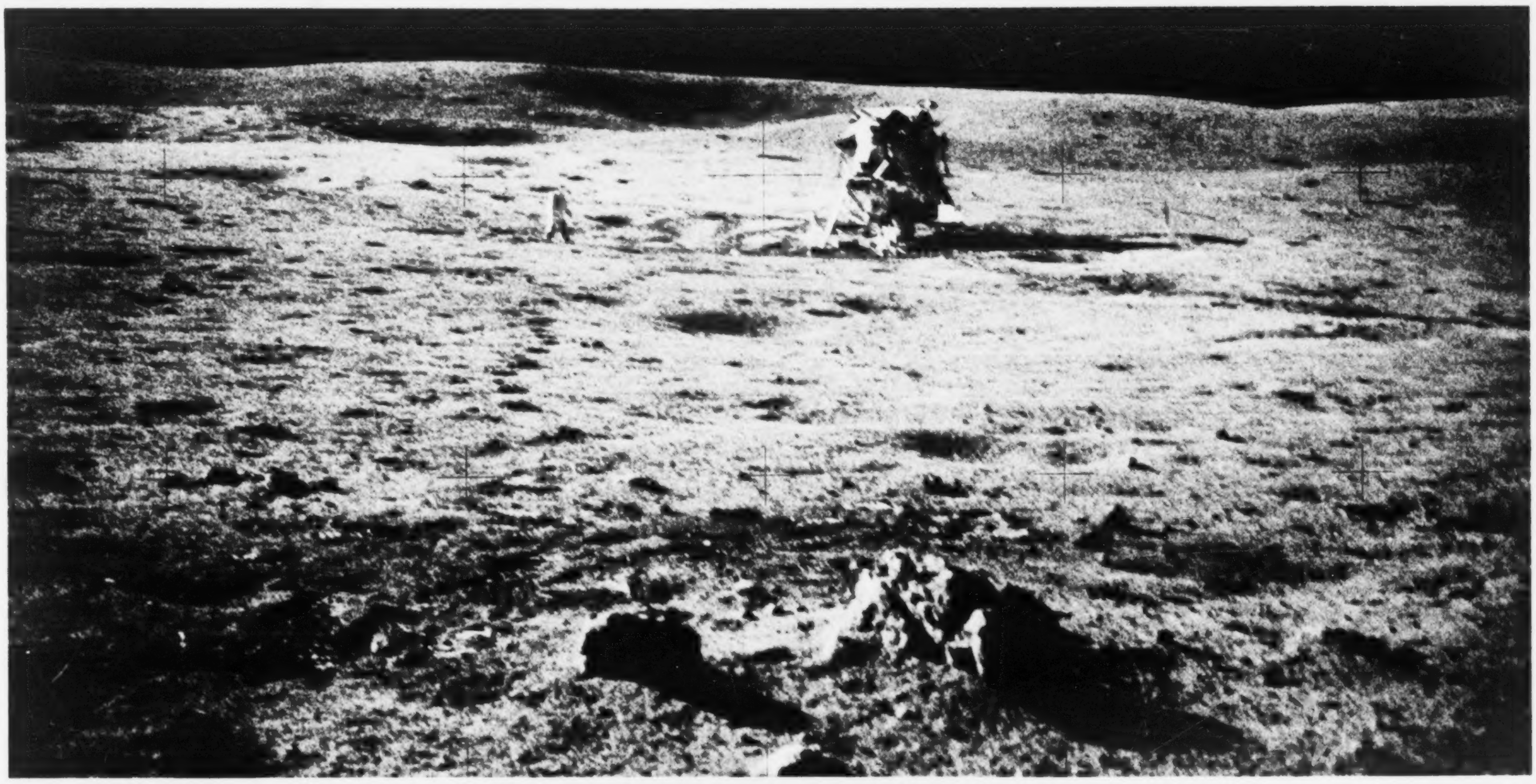
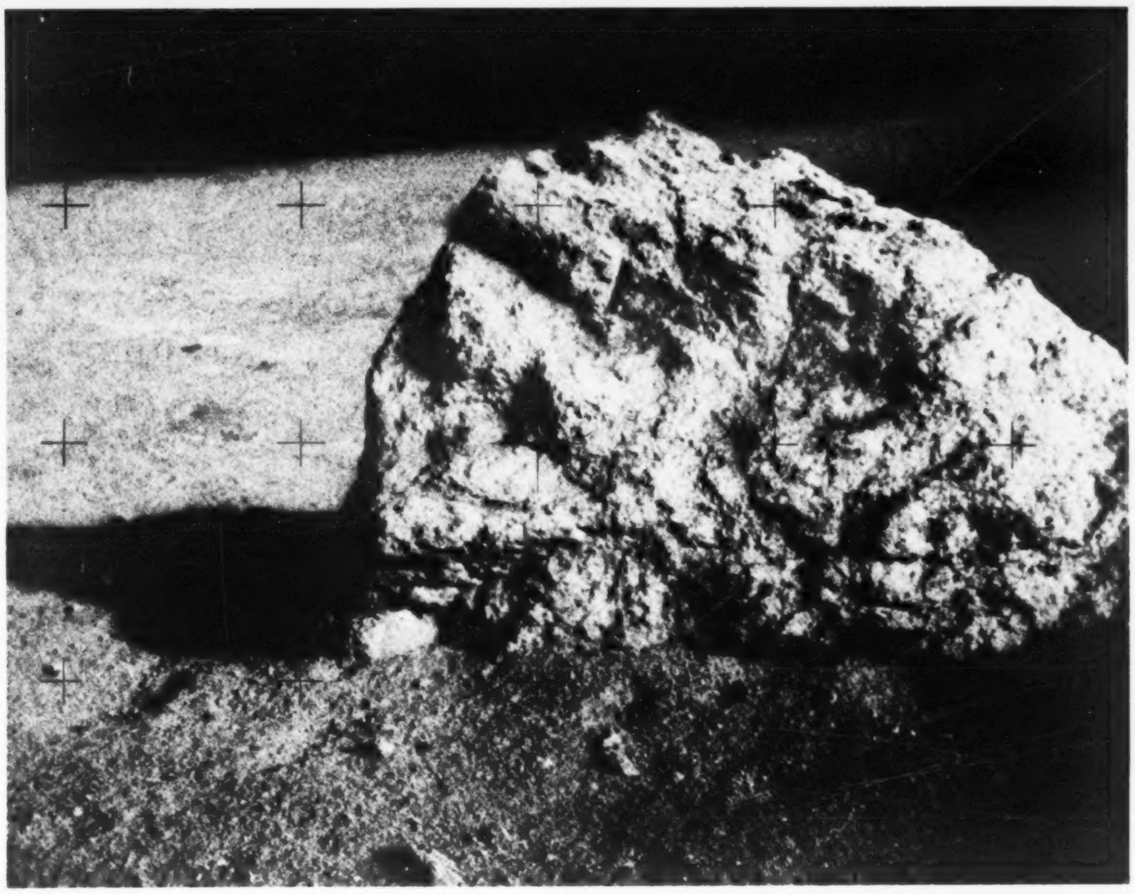
The hills of Fra Mauro stretch in every direction as one of the Apollo 14 astronauts walks toward Antares, parked in valley.





Large boulders like this one were abundant on the lunar surface. Apollo 14 brought back to Earth the largest and greatest variety of Moon samples ever seen by scientists.

This automated laboratory began recording and transmitting data to Earth almost at once after Apollo 14 astronauts set it up on the Moon.

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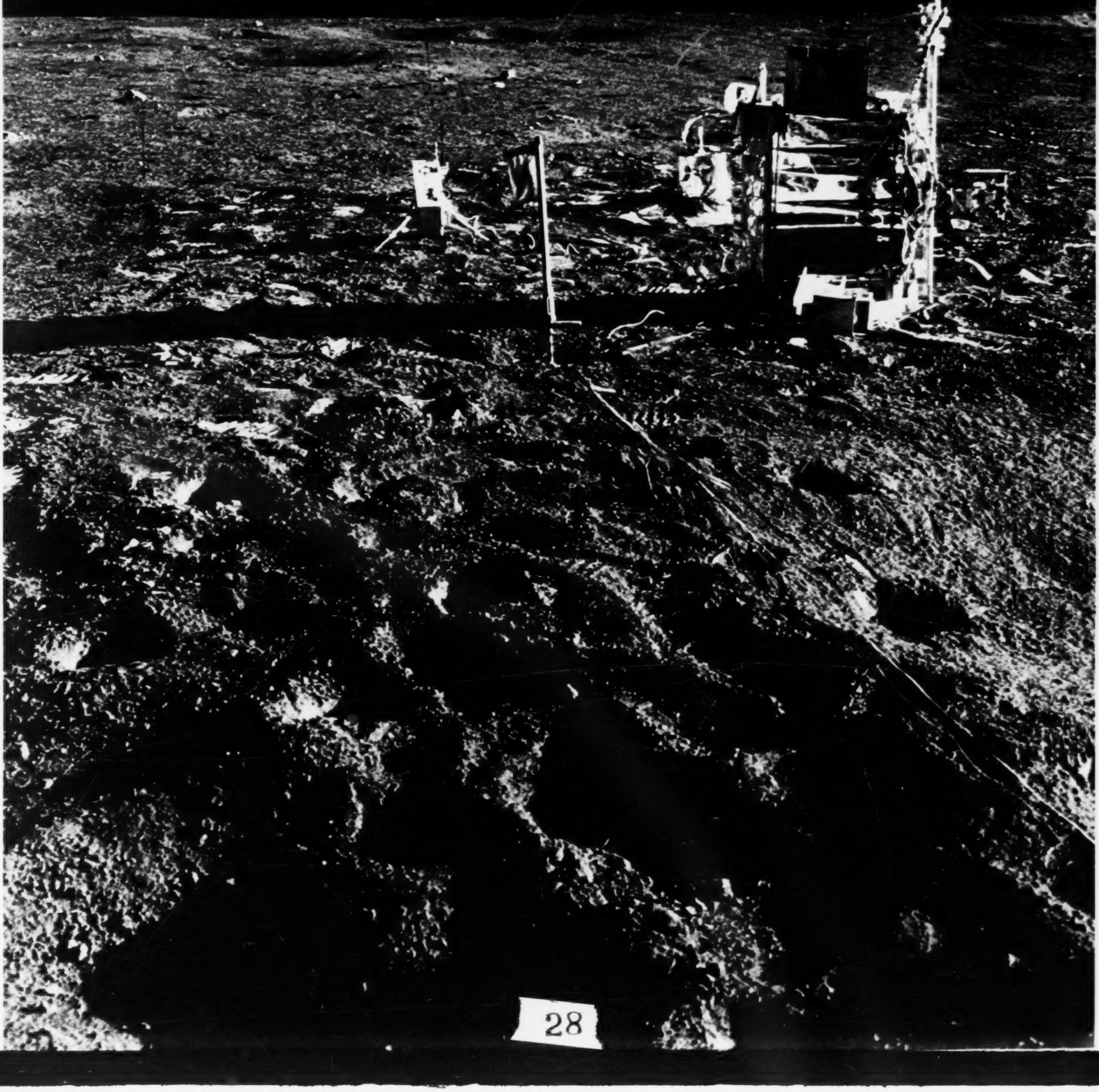

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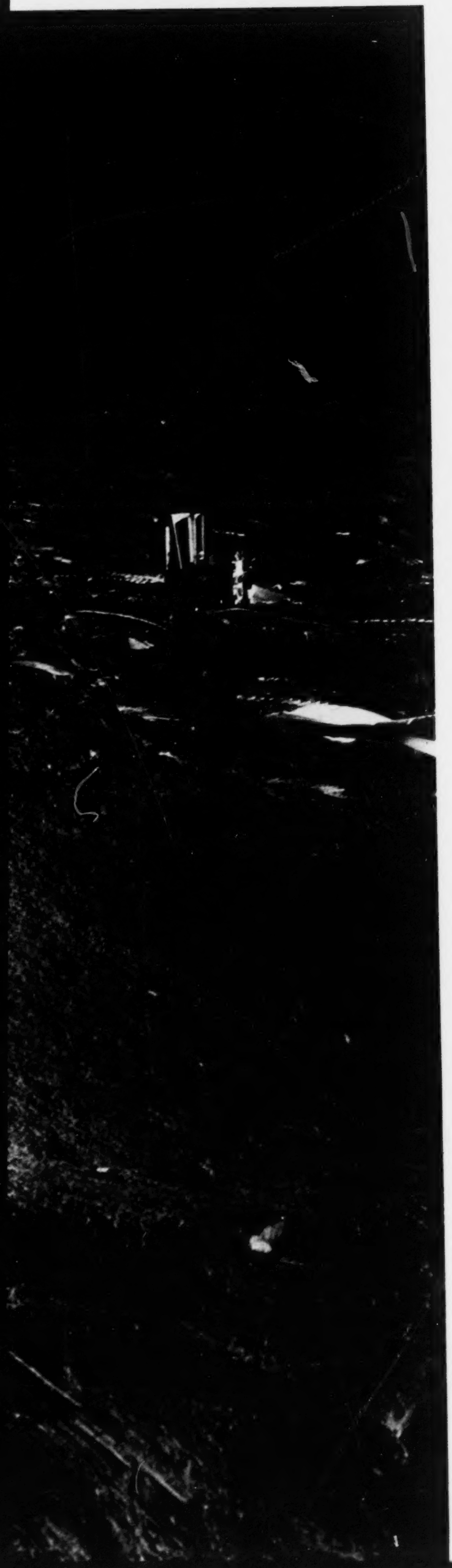


of grapefruit or bowling ball size.

Shepard joined him inside the craft and they closed the hatch. The two men had inscribed themselves on the pages of history.

That second Moon excursion had taken the men on a longer traverse across the Moon than any previous one—3,300 feet (one kilometer) from Antares, compared with the 200 feet (60 meters) the Apollo 11 astronauts had walked from their landing craft, and the 1,400 feet (420 meters) the Apollo 12 crew had gone. That second excursion also had added four hours and 35 minutes to Shepard's Moon walk time which now totaled nearly 9½ hours—a new record for one person. Mitchell, who had left Antares a few minutes after Shepard and returned a few minutes ahead of him on each walk,was a close second in time spent on the lunar surface outside a spacecraft. Together, the men had accumulated nearly 19 man-hours of "extravehicular activity" or "EVA" on the Moon and, thus almost doubled the lunar EVA time of astronauts to nearly 40 man-hours.

The total of about 95 pounds (43 kilograms) of Moon rock and soil brought back to Earth by Apollo 14 also was a record. Apollo 11 came back with 46 pounds (21 kilograms), and Apollo 12 retrieved 75 pounds (34 kilograms).

The major goal of Apollo 14 was the scientific exploration of the Moon in the foothills of the rugged Fra Mauro region. The astronauts had set down in that region at 4:18 (Eastern Standard Time) on the morning of Friday, February 5, to a pinpoint touchdown only eighty-seven feet (26 meters) north of the target point mapped out for them.

Six hours and 35 minutes after their arrival, Shepard and Mitchell opened the hatch of the Antares, stepped out onto the surface of the Moon, conducted scientific experiments and set up an automated scientific laboratory called ALSEP (Apollo Lunar Scientific Experiments Package).

The instruments began transmitting information to Earth, almost at once, to the delight of scientists. Within hours of these first transmissions, some of the principal investigators explained details at press conferences. They interpreted the information that was being received and showed how it was being used to determine the Moon's structure and physical properties and to analyze the radiations on its surface.

The scientists said Apollo 14's ALSEP instruments were the best ever taken to the Moon, and there was every reason to believe the instruments would continue transmissions for at least a year, which they were designed to do.

In one ALSEP experiment, Mitchell used a "thumper" to send shock waves traveling through the Moon's upper layers for detection by sensors which reported the vibrations back to Earth.

That first Moon walk was going so well that Mission Control allowed the astronauts to extend it beyond the originally planned four hours and 15 minutes. The extension permitted the astronauts to expand their Moon rock collection to 44 pounds (20 kilograms) and to add still more panoramic photographs and stereo closeup pictures of Moon surface features.

When the astronauts crawled back into Antares and closed its hatch four hours and 50 minutes after they had opened it, they had achieved a new endurance record for continuous Moon walking. After eating and resting, they began their second Moon walk which eventually set a record for distance with their geological traverse toward Cone Crater.

Apollo 14 was the world's 40th manned space flight, the 24th for the United States. It was history's third successful manned Moon landing mission, the first in the decade of the 1970's. The mission brought to nearly 200 the man-hours astronauts have lived on the surface of the Moon and to more than 6,910 the man-hours astronauts have lived in space. It is an amount equal to one man living in space for 9 months, 17 days and 22 hours.

Astronaut Roosa in the command module completed 34½ revolutions around the Moon, thus bringing to 150 the number of lunar orbits flown by manned space craft. (10 by Apollo 8 in December 1968; 31 by Apollo 10 in May 1969; 30 by Apollo 11 in July 1969; and 45 by Apollo 12 in November 1969.)

Shepard, who turned 47 years old on November 15, 1970, became the oldest American to fly in space and the oldest person to land on the Moon. He and Mitchell, who became 40 on September 17, 1970, were the fifth and sixth persons, respectively, to walk on the Moon.

The continuous telecasts, lasting several hours during each of the two Apollo 14 Moon walks, were the first significant lunar scenes to be transmitted to Earth in color, live from the Moon. Though the Apollo 12 LM carried a color television camera, it ceased functioning after only a few minutes' use when direct sunlight entered the lens and singed vital components. When it ceased functioning, its sole transmissions had consisted of showing one of the astronauts descending the LM ladder. To prevent any recurrence of similar damage, the Apollo 14 color TV camera was designed to withstand accidental exposure to direct sunlight, and also was outfitted with lens caps for use while the astronauts moved the camera. It provided color transmission from the moment it was activated while Shepard was descending Antares' boarding ladder for the first Moon walk until after the second Moon walk when the camera's power connection to the LM was intentionally severed before the astronauts' liftoff.

Apollo 14, with its prime aim of exploring the Moon's Fra Mauro region—a virtual lunar geological museum—was in a sense a search into the past. If scientists can unravel nature's coded messages from the retrieved Fra Mauro rocks, and trace from them the evolution of the Moon, or even the Earth and the entire solar system, Apollo 14 would stand as the culmination of one of mankind's primeval ambitions.

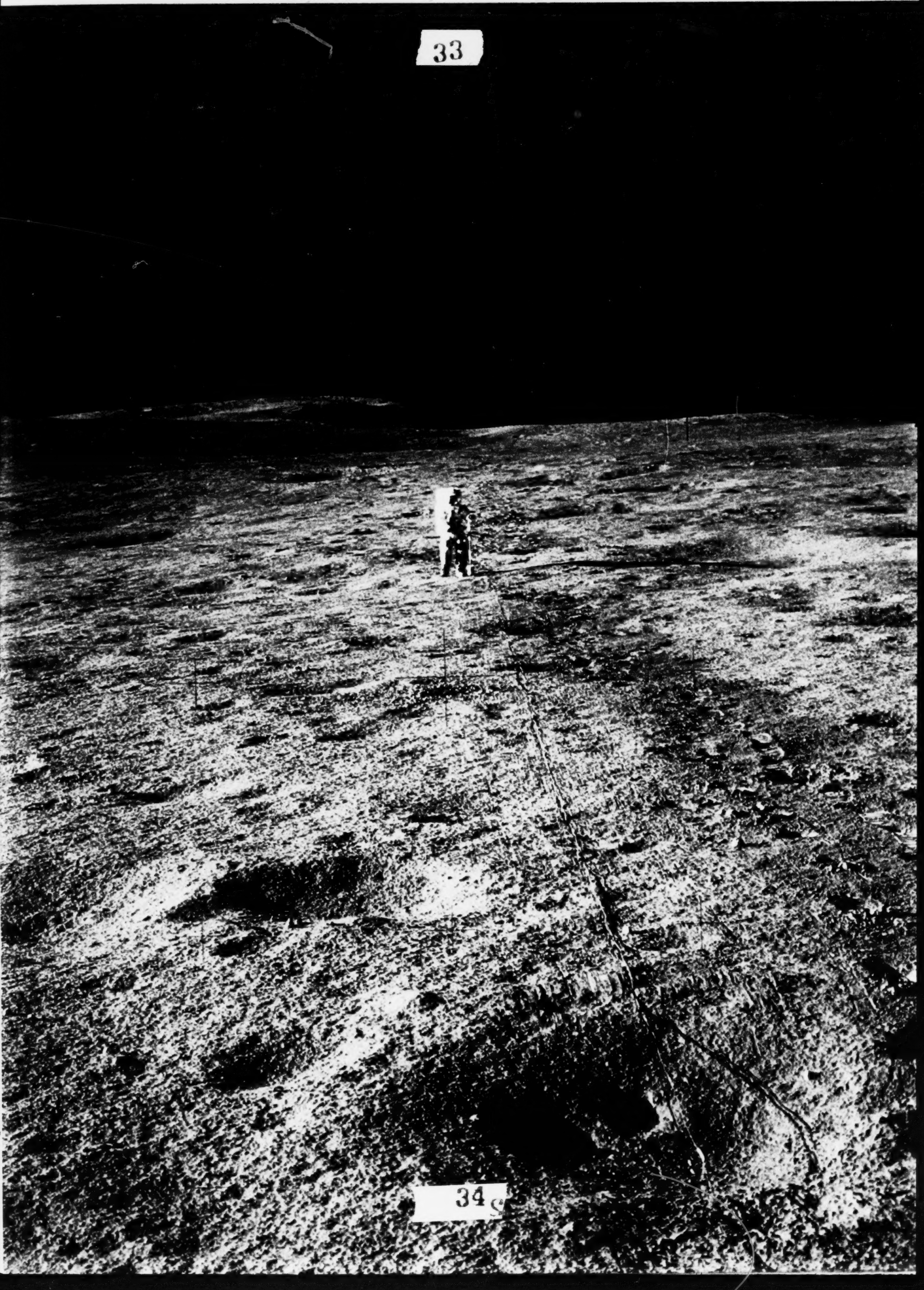
But, equally, Apollo 14 was a thrust into the future. The flight was the last of what space engineers have designated as "H" missions. That series is now to be followed by the "J" missions with a substantially advanced stay capacity on the Moon. The J series landing craft have enlarged propellant tanks, an additional battery, more life support supplies, and provisions for the Rover.

Each of the three planned J missions, Apollo 15 through 17 later in 1971 and in 1972, is designed to allow a pair of astronauts to spend three separate Moon walk periods of up to seven hours each on the lunar surface, thus more than doubling the mission exploration time for each astronaut over that which Shepard and Mitchell could obtain. All Moon flight crews until now have expressed regret that their equipment limited their stay time on the lunar surface and their conviction that they could have completed additional research tasks if they had been allowed to remain longer outside the spacecraft.

As an engineering achievement, Apollo 14 made a profound contribution to the advancement of space exploration and lunar science. This was particularly emphasized by the techniques with which the astronauts and technical personnel worked together as an Earth-space team. Across distances stretching tens of thousands of miles, the Moon travelers and ground crews exchanged information and developed solutions and counteractions to overcome a variety of technical irregularities and engineering problems.

Long before the flight of Apollo 14, the mission's launch date and the name of its commander were already key imprints in the annals of space exploration.

Detonating small explosive charges as he walks, Astronaut Mitchell imparts slight shocks to the Moon's surface with a "thumper." The shocks are recorded by three sensors that had been implanted along the route.



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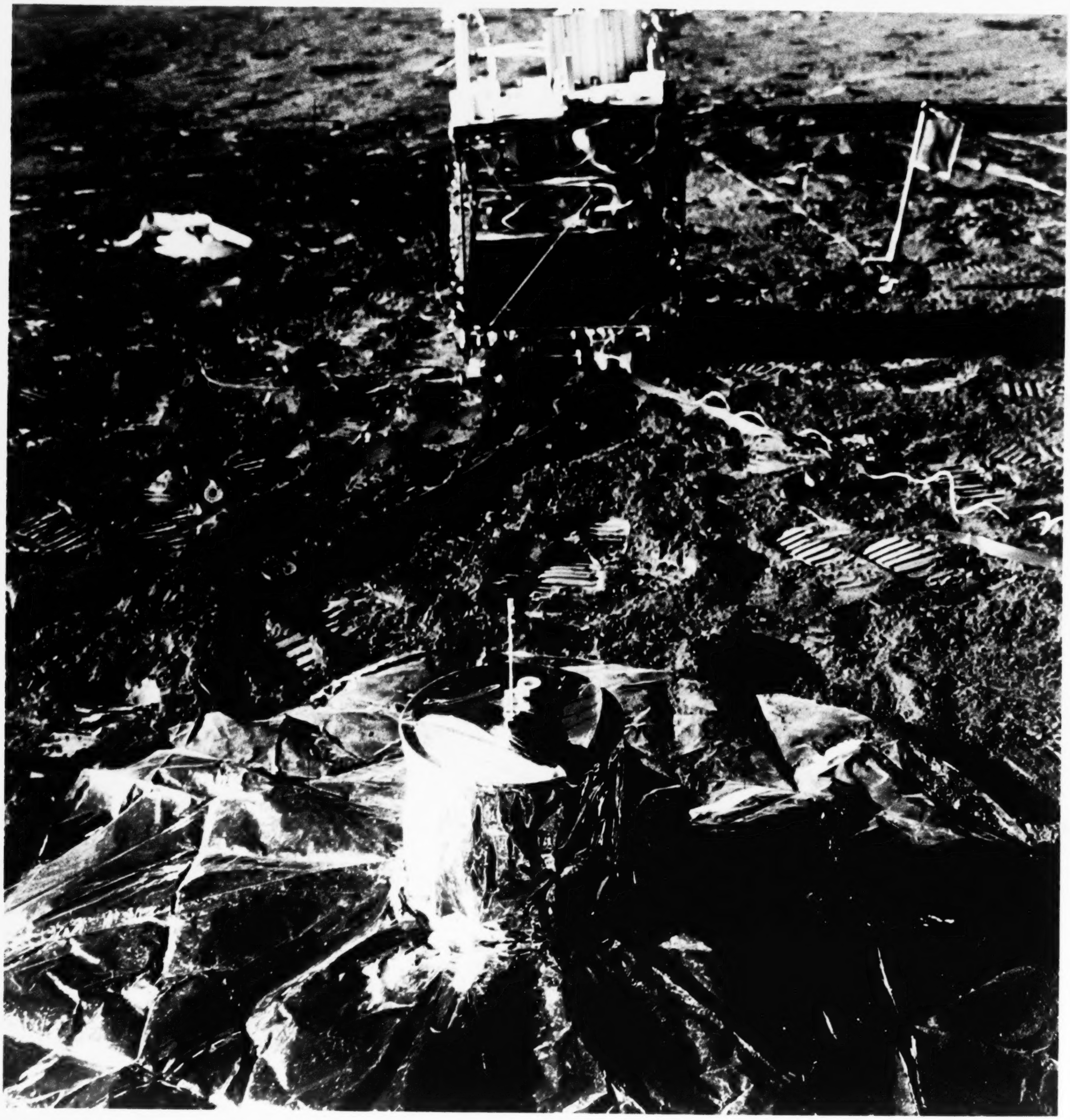
Moonquake detector (also known as a seismometer or passive seismic experiment) in foreground is part of ALSEP, the Apollo Lunar Scientific Experiments Package, the automated laboratory established by Apollo 14.



By coincidence, Apollo 14's launch date, January 31, 1971, fell on the 13th anniversary of the launching of America's first Earth satellite. It was on January 31, 1958, that a 68.6-foot (20.5 meter) tall Jupiter-C rocket raised itself off its pad at Cape Canaveral (later renamed Cape Kennedy), Florida, carrying the Explorer I satellite, a bullet-shaped capsule. Though a portion of the rocket remained attached to Explorer I as it went into orbit, the combined orbiting assembly still measured only 80 inches (203 centimeters) in length and weighed only 30.8 pounds (13.86 kilograms).

In contrast, Apollo 14 injected itself into Earth orbit weighing about 300,000 pounds (135,000 kilograms, including the attached third stage (S–IVB) rocket, thus becoming the heaviest man-made object in Earth orbit—nearly 10,000 times as much as that first U.S. orbiter.

Likewise, Apollo 14 Commander Shepard was known before his Moon flight for his pioneering efforts in space. He was the first American to fly through space.

That first flight on May 5, 1961—nearly 10 years before Apollo 14—lasted only 15 minutes and 22 seconds from liftoff at Cape Canaveral to splashdown in the Atlantic Ocean only 302 miles (486 kilometers) away. The flight was called "suborbital" because Shepard's craft, Freedom 7, was not inserted into orbit, but was instead, deliberately boosted into an arc-like path that reached its peak at an altitude of 116.5 miles (187.5 kilometers) before beginning its descent and re-entry into the atmosphere. Shepard's top speed in Freedom 7 was 5,180 miles (8,288 kilometers) an hour. He was weightless for only five minutes.

In contrast, Apollo 14 accelerated Shepard and his two crewmen to a peak speed of about 24,000 miles (38,000 kilometers) an hour during the early boost phase toward the Moon and just before re-entry into the Earth's atmosphere. The men were weightless for several days. The Saturn V launch vehicle that lifted them from the Earth was sufficiently powerful to inject 60 of the one-man Mercury capsules into Earth orbit simultaneously. The Apollo 14 spacecraft alone, minus the Saturn V, weighed nearly one and one-half times as much as Shepard's combined Mercury capsule and the Redstone rocket that lifted him into space on his first flight. The Apollo 14 craft was only two feet (60 centimeters) shorter than Shepard's first rocket and spacecraft combined.

Primitive as Shepard's first flight seems by today's standards, it gave new confidence and inspiration to the then fledgling U.S. space program. Shepard's detailed descriptions gave the world its first eye witness account of the view of the Earth from space and of the sensations and reactions and impressions generated by such a journey.

Shepard's flight served notice on the world that the United States was determined to achieve preeminence in space. President Kennedy delivered a major address on space exploration to the Congress on May 25, 1961—less than three weeks after the Shepard mission. The President suggested that the United States set itself as a national goal the attainment of a manned Moon landing before the end of the 1960's. That presidential address has become accepted by historians as the beginning of the program which led to the Apollo 14 flight. Thus it might be said that Shepard has now come full circle in the American space exploration program.

Even before Apollo 14's Moon landing, valuable scientific data emerged from the journey. The spacecraft was behind the Moon, out of tracking and communications contact with Earth, and the astronauts had just slowed the craft to insert it into Moon orbit. At that time, 2:41 in the morning of Thursday, February 4, Eastern Standard Time, the uppermost portion of the Saturn V rocket, the S–IVB stage, collided with the Moon, as it was programmed to do.

By propelling the Apollo spacecraft out of Earth orbit into a Moon trajectory, the S–IVB had also boosted itself on a Moon course and, by remote control, was steered on a lunar collision course. The force of the impact equalled the detonation of 11 tons of TNT. The Moon reacted like a gong. For about three hours it vibrated and these vibrations traveled to a depth of from 22 to 25 miles (35 to 40 kilometers). The concussions were sensed by a Moonquake detector, a

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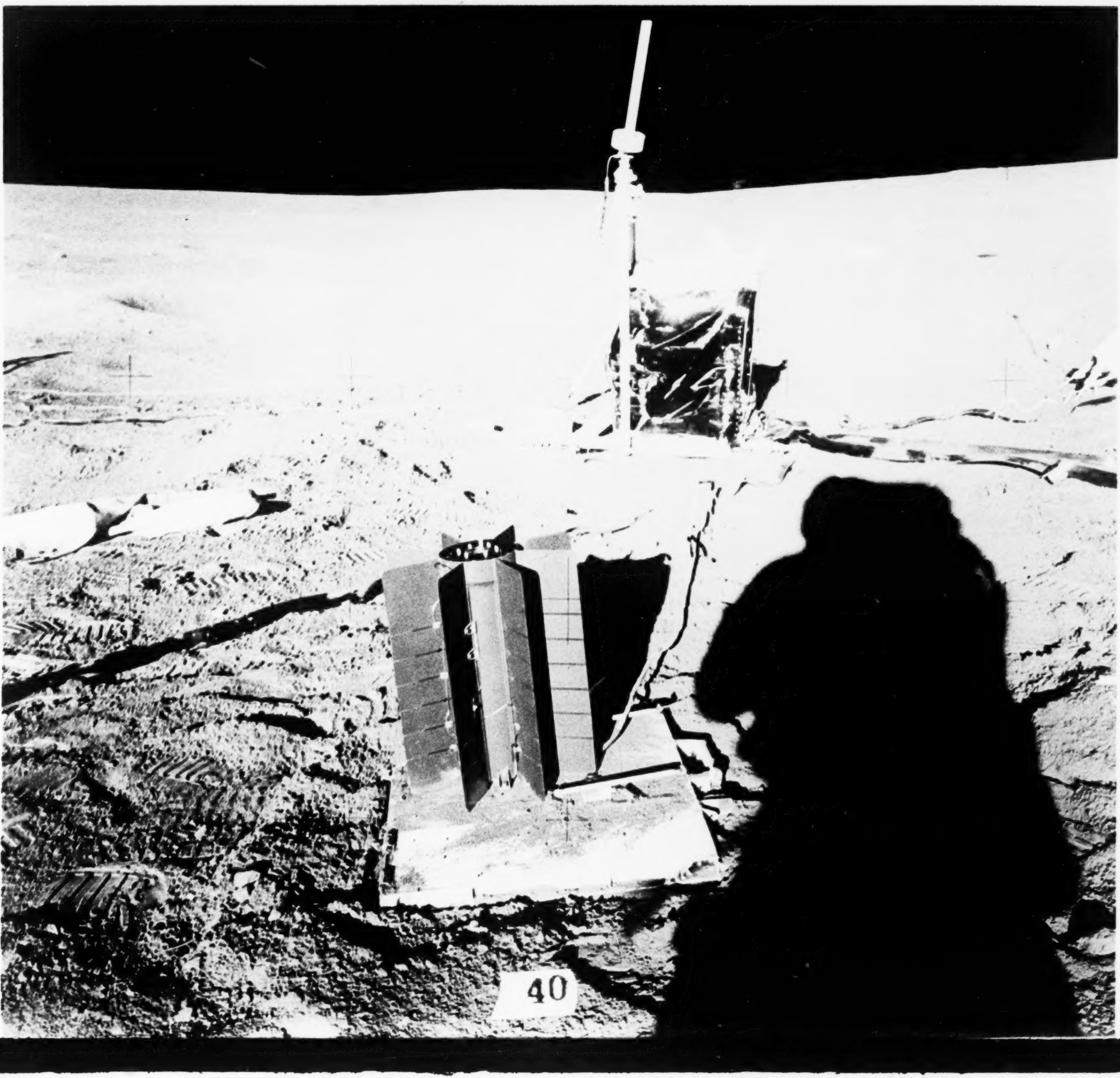
With a thumper, which is part of the active seismic experiment, Mitchell tests subsurface layers. Shepard stands still in background to avoid interfering with thumper signals.

The nuclear power plant in the foreground is the radioisotope thermoelectric generator (RTG) which is connected to scientific instruments to provide them with needed electricity.



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seismometer that had been set up by the Apollo 12 astronauts in November 1969 in the Moon's Ocean of Storms about 108 miles (173 kilometers) south-southwest from the impact site. The seismometer's measurements were automatically relayed to Earth by radio through a robot transmitter at the Apollo 12 site. Scientists analyzing the data said it appears to confirm earlier conclusions that the composition of the Moon's outer layers to a depth of about 22 miles (35 kilometers) is uniform throughout. The scientists said that variations in properties of materials within that area apparently are due solely to compression from the weight of overlying materials.

That tentative opinion was strengthened later in the Apollo 14 mission by the results of a similar, but scientifically even more valuable experiment shortly before the astronauts rocketed themselves out of Moon orbit and onto a path back toward Earth.

After completing their second Moon walk, returning to Moon orbit and rejoining the main spacecraft, the astronauts jettisoned the upper section (ascent stage) of their landing craft which by then was no longer needed.

By radio command from Mission Control, the empty 4,850-pound (2,200 kilogram) ascent stage was then steered toward the Moon. It struck with a force equal to the explosion of about 1,600 pounds (725 kilograms) of TNT and induced tremors lasting about 90 minutes. This minor Moonquake marked a scientific milestone. It was the first time any event, manmade or natural, was recorded by a network of two seismic stations on the Moon. The seismometer at the Apollo 12 site had been supplemented by a similar machine installed by the Apollo 14 astronauts in the Fra Mauro region.

Scientists pointed out that in this kind of experimentation, one plus one equals more than two. By comparing and correlating information from the two seismometers at precisely known, but widely separated locations, scientists are able to trace the shock waves of the impact and deduce facts about the Moon's structure with far greater accuracy than from only one station.

The LM ascent stage struck at a point between the two stations—about 44 miles (70 kilometers) northwest of the Apollo 14 station and about 71 miles (114 kilometers) southwest of the Apollo 12 station. The Moon's reaction followed what has become known from previous similar impacts as characteristic lunar behavior: The reverberations built up to a crescendo, then gradually decayed.

Dr. Gary Latham, the principal investigator for the Passive Seismic Experiment, said this behavior still baffles scientists who have found no counterpart on Earth.

The current interpretation of the unusual reaction is that the impact force was widely scattered by the Moon's structure.

Dr. Latham explained: "In my opinion, it means very likely, that the structure has been essentially pulverized by continuous meteorite bombardment since formation 4.6 billion years ago or so, and that at least the upper few kilometers are very, very broken up material."

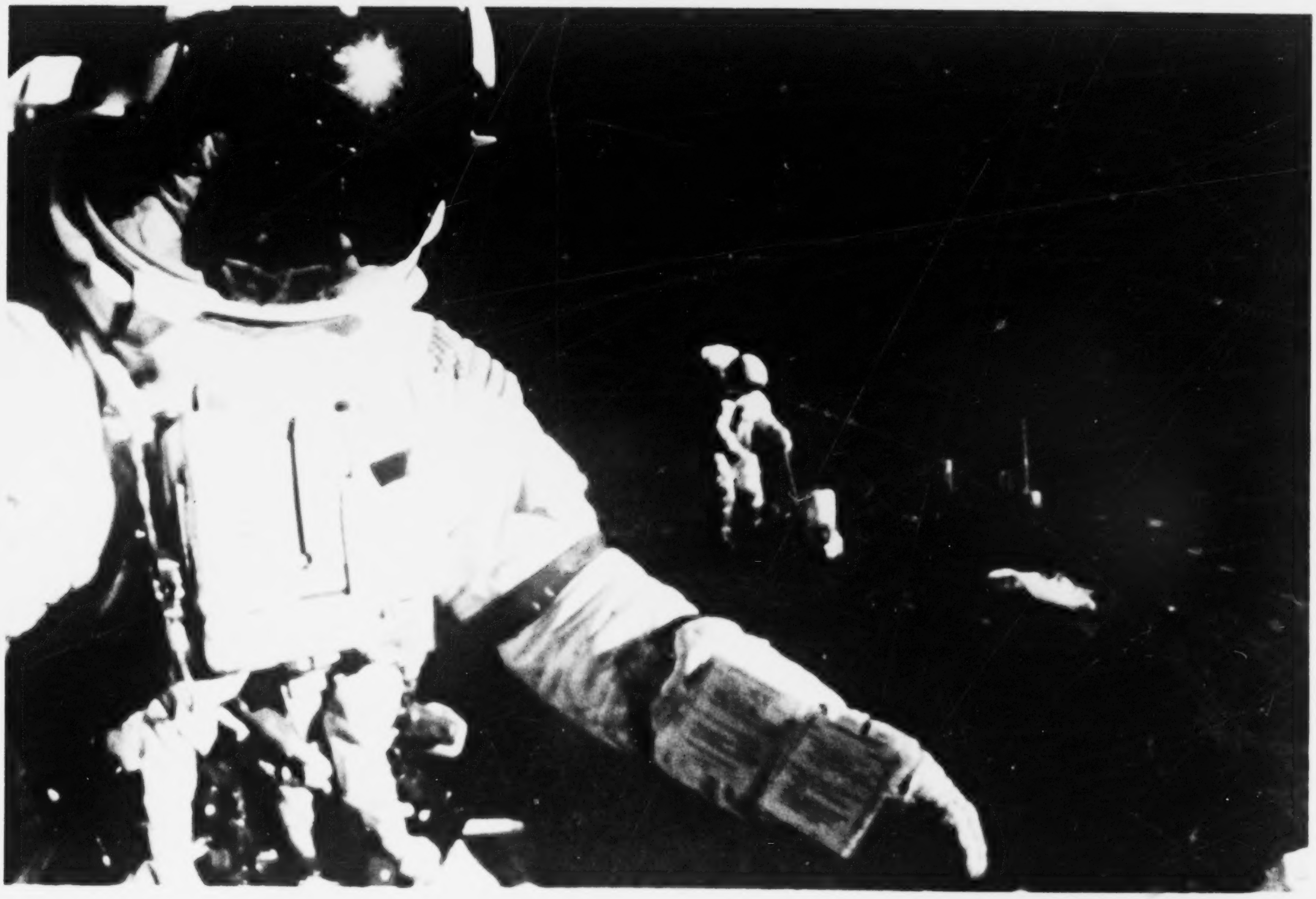
The scientists measured the time from the impact to the moment the first shock waves were sensed at each station. The size of the interval indicates to the investigators the kind of material through which the seismic waves travel. Dr. Latham said this analysis leads the scientists to believe the same kinds of materials retrieved by astronauts from the surface extend to a depth of about 22 to 25 miles (35 to 40 kilometers).

As for the recovery by astronauts of igneous rocks (those which have solidified after melting as from lava flow), Dr. Latham said some of the rocks were apparently thrown onto the surface after meteorite impacts gouged them out from deep inside the Moon's interior. Also, he said there is evidence of melting that occurred about a million years after the Moon's formation—or about 3.3 to 3.6 billion years ago—and scientists theorize this melting occurred from heat escaping from radioactive decay deep inside the Moon.

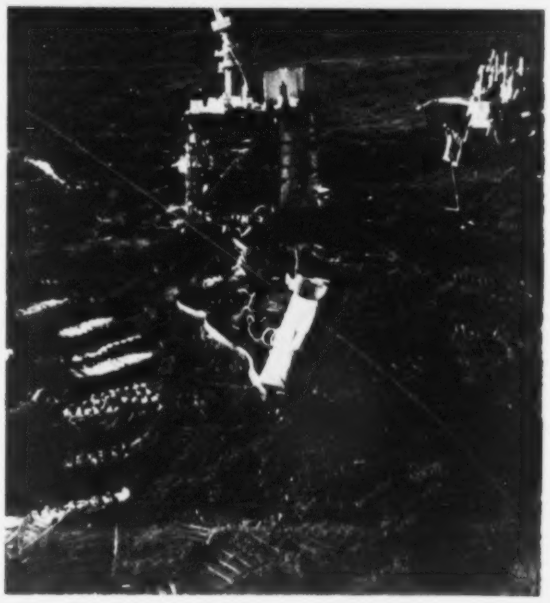
The scientists were eagerly looking forward to the occurrence of the first natural Moonquake to be recorded by their new network and toward the establishment of a third network station by Apollo 15 in mid-1971.

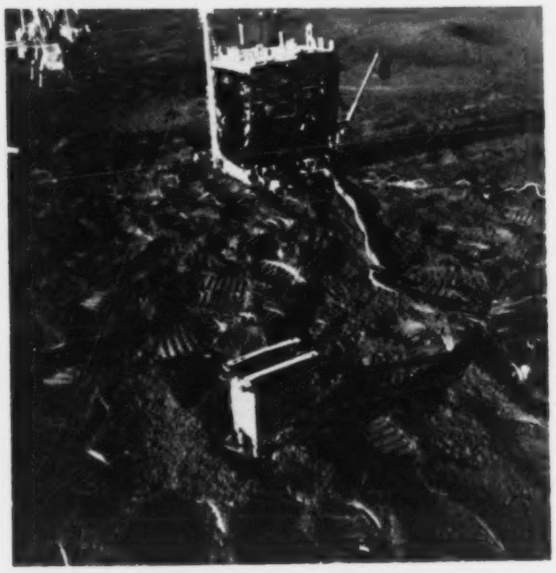
The Apollo 14 seismometer, like Apollo 12's, was part of an automated scientific laboratory set up by the astronauts on the Moon. Aside from rock collecting, nearly

Photograph taken by an automatic camera mounted on the astronauts' pull cart shows Shepard, foreground, consulting notebook-like checklist attached to left wrist while Mitchell adjusts research instruments.



Grenade launcher in foreground was installed on Moon by Apollo 14 astronauts to be activated from Earth, later in 1971. Impact of its four missiles will be sensed by automatic devices.





That metal box in foreground is a charged particle lunar environment experiment (CPLEE). It detects atomic particles that arrive on the Moon from the Sun and space.

the entire first Moon walk period of Apollo 14 was taken up by establishing a robot laboratory called ALSEP, meaning Apollo Lunar Scientific Experiment Package. The seismometer and most of the other experiments in that package were designed to continue operation for at least one year after the astronauts' departure from the Moon. A small nuclear power generator in ALSEP is providing the necessary electricity for operating the instruments, the heaters that keep them warm during the cold two-week-long lunar night and the automated radio transmitter that relays information to Earth. After Shepard and Mitchell installed the array and turned on the power, signals were immediately received by scientists at Mission Control.

The most spectacular ALSEP experiment, however, did not involve such long-duration accumulation and transmission of data. It was what scientists call the "active seismic experiment" and it consisted of small explosions set off on the Moon so that sensing devices could measure the resulting small vibrations as they traveled through and below the lunar surface.

One part of this active seismic experiment consisted of a "thumper," a device resembling a large diameter walking stick. A plate at its bottom was designed to strike the Moon each time Mitchell pulled a lever at 15-foot (4.5-meter) intervals as he walked with the device. Only 13 of the thumper's 21 charges went off. But the scientists were satisfied. Vibration detectors, called "geophones," which Mitchell had earlier laid out on a cable at 150-foot (45-meter) intervals, recorded the seismic waves. Scientists who received the signals said they were sufficient for the purposes of the experiment.

The other part of the active seismic experiment is a grenade launcher. Mitchell set it up so that it faced away from the working and excursion area. Later in 1971 scientists will activate it by remote control so that each of the four grenades it holds will be thrown to detonate at a different distance – 500 feet (150 meters), 1,000 feet (300 meters), 3,000 feet (900 meters) and 5,000 feet (1,500 meters) – from the launcher. Again, the sensors are to pick up the vibrations for transmission to Earth from ALSEP's central radio station.

Also connected to that central station are the other ALSEP experiments: "Charged Particle Lunar Environment Experiment" (CPLEE), "Cold Cathode Ionization Gauge" (CCIG), "Suprathermal Ion Detector" (SIDE) and the "Lunar Dust Collector."

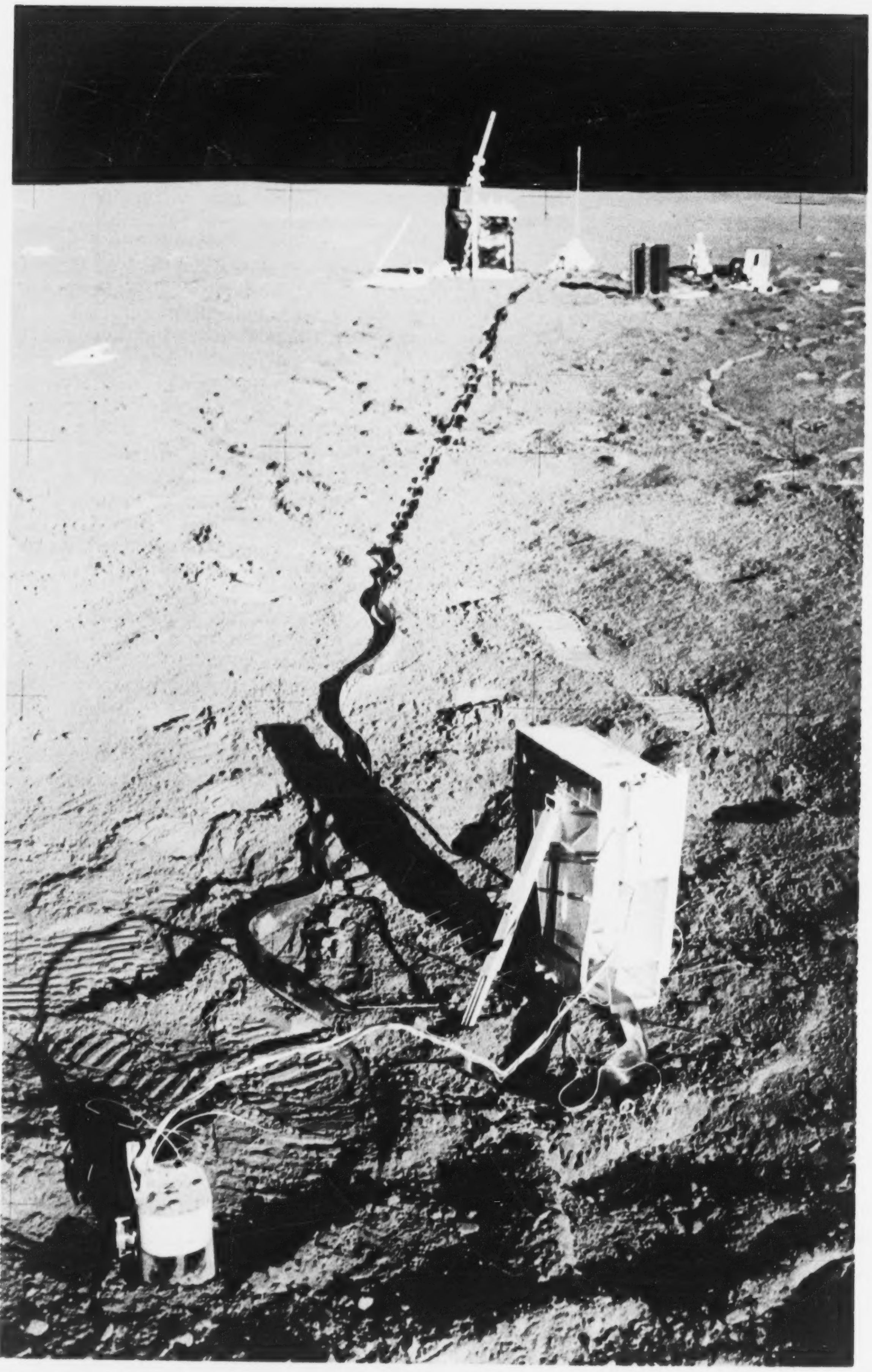
Dr. Brian O'Brien, a physicist from the University of Sydney and principal CPLEE investigator, explained his machine's status. "The experiment has been working absolutely perfectly to date," he declared. "Just after it was switched on the experiment was apparently immersed in a sea of low energy electrons that we associate with the comet-like tail blown back by the solar wind."

He was referring to the Earth's magnetic field which sweeps trapped particles through space somewhat like a comet's tail. But the Sun's solar wind blows these particles so that the tail becomes curved or distorted. The CPLEE is designed to measure electrons and protons and other atomic particles that bombard the Moon from space. In this way, the CPLEE is a step toward answering the perplexing questions about the workings of the Earth's magnetic environment or, as scientists call it, the Earth's magnetospheric system. Dr. O'Brien said his experiment also detected particles which appeared remarkably similar to those found in auroras, the Northern and Southern Lights. These celestial phenomena caused by electrified particles in space, have puzzled men through the ages, and scientists today still cannot fully explain the source of their prodigious energies.

Dr. O'Brien's co-investigator, Dr. David Reasoner, a physicist of Rice University in Houston, Texas, monitored the CPLEE during the ascent stage's crash on the Moon. He said the impact vaporized rocks and dust. Sunlight, unobstructed by any atmosphere, acted on the vapor so as to break up its atoms and produce charged atomic particles, ions and electrons. Within 50 seconds of the ascent stage impact, Dr. Reasoner noted that the instrument's counts of electrons and ions suddenly increased tremendously, then dipped and increased again before returning to the original "normal" rate.

Dr. Reasoner explains his findings by theorizing that two clouds of particles, generated and impelled by the ascent

Density, flow and energy of certain atomic particles on the Moon are detected by the instrument in foreground. The device is a suprathermal ion detector (SIDE). The small round device is an "atmosphere detector" known to scientists as the cold cathode ionization gauge (CCIG).



stage's impact, moved across the Moon at a speed of more than 1,800 miles (2,900 kilometers) an hour and passed his instrument 44 miles (71 kilometers) from the impact site beginning at about 50 seconds after ascent stage collision.

Thus, said Dr. Reasoner, Apollo 14 has added a new dimension to the study of particles in space begun with Explorer I in 1958. For the first time, man has placed a particle detector on a stable space platform – the Moon – and then initiated a carefully controlled particle experiment – the ascent stage impact – to provide unprecedented information that may lead to an understanding of many space phenomena.

The other ALSEP experiments have all been tested on the Moon before in the Apollo 11 or 12 flight or in both. The Suprathermal Ion Detector measures the density, flow and energy of atomic particles of different types than those counted by the CPLEE.

Dr. John Freeman, principal SIDE investigator, said the instrument left on the Moon by the Apollo 12 astronauts and in operation there for nearly 15 months, detected particles generated by the exhaust of the descent engines of Apollo 14 during the astronauts' landing and later again from the ascent engines when the astronauts launched themselves from the Moon. About six and one-half minutes after Apollo 14's liftoff from the Moon, Dr. Freeman said he "saw" gas clouds on his monitors in the form of very intensive flows of positive ion particles. Thus, he said, in a way, the Apollo 12 SIDE said hello and goodbye to the Apollo 14 astronauts as they came and left the Moon. He said this proves the amazing sensitivity of the instrument and its high level of performance.

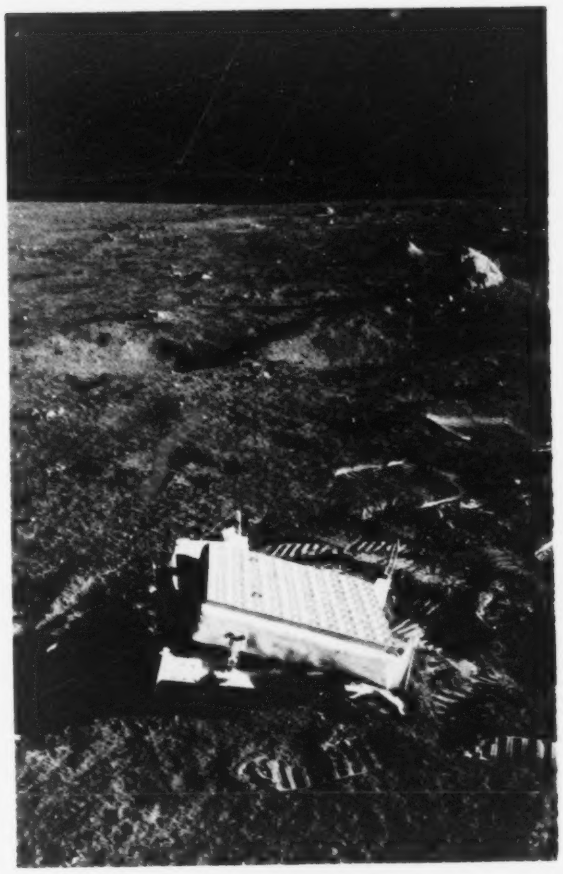
The Cold Cathode Ionization Gauge is, in effect, an atmosphere detector. It analyzes gases which are escaping from the rocks and the Moon's interior in minute quantities, or arrive on the Moon from the Sun. Because of the Moon's weak gravitational pull, these gases quickly disperse into space.

Dr. Freeman said the instrument noted gases shortly after the Apollo 14 astronauts depressurized (vented the air from) their landing craft and also when the astronauts walked in certain areas of the Moon. The gases from the astronauts are believed to have escaped from their oxygen supply for breathing or from the cooling fluids in the portable life support system.

The astronauts also set up two other experiments, independent of ALSEP. One is known as a Laser Ranging Retro-Reflector. It consists of 100 reflective quartz cubes which the astronauts adjusted so they face toward the Earth. Concentrated light beams from lasers can be directed from Earth to the instrument which reflects them back to Earth. By measuring the time consumed for the roundtrip, scientists can determine Earth-Moon distances, and also distances between points on Earth, with unprecedented precision. Even while the Apollo 14 astronauts were still on the Moon, astronomers at McDonald Observatory in Texas bounced laser beams off the newly emplaced device and reported it worked as expected. The astronomers are attempting to determine movements of the Earth's crust and the slight wobble of the Earth that normally occurs as it spins on its axis. Eventually, similar measurements with the Moon reflector may determine whether the Earth's continents move closer or away from each other and, if so, at what rate this continental drift is occurring. The reflector is expected to remain useful on the Moon for many years.

The other experiment, nicknamed the "Window Shade Experiment," consists of a specially prepared aluminum foil which the astronauts unrolled from a pole after stamping the pole into the lunar soil. The foil trapped gas particles arriving at the Moon from the Sun. Before liftoff, the astronauts rolled up the foil and stowed it in the craft for return to Earth where scientists are now examining the foil. That experiment, known as the "Solar Wind Composition Analysis," has been conducted during every manned Moon landing.

Apollo 14 was predominantly a scientific research venture. As information poured in from the array of instruments on the surface of the Moon and from the astronauts themselves, scientists repeatedly told newsmen at press briefings that they were pleased and satisfied. Analysis of the masses of data, examination of the large quantity of Moon rocks and soil, and careful study of the



A hundred quartz mirrors make up the face of this instrument, the laser ranging retro-reflector (LR–3). It bounces laser light beams back to Earth when scientists aim them at the Moon, for distance measurements.

Panoramic view shows instruments of ALSEP automated laboratory in a circular array. Astronaut Mitchell returns to the landing craft after arranging them. Fra Mauro highlands region was selected as Apollo 14 landing site because some rocks there are believed to have remained unchanged since the Moon and the rest of the solar system were formed.

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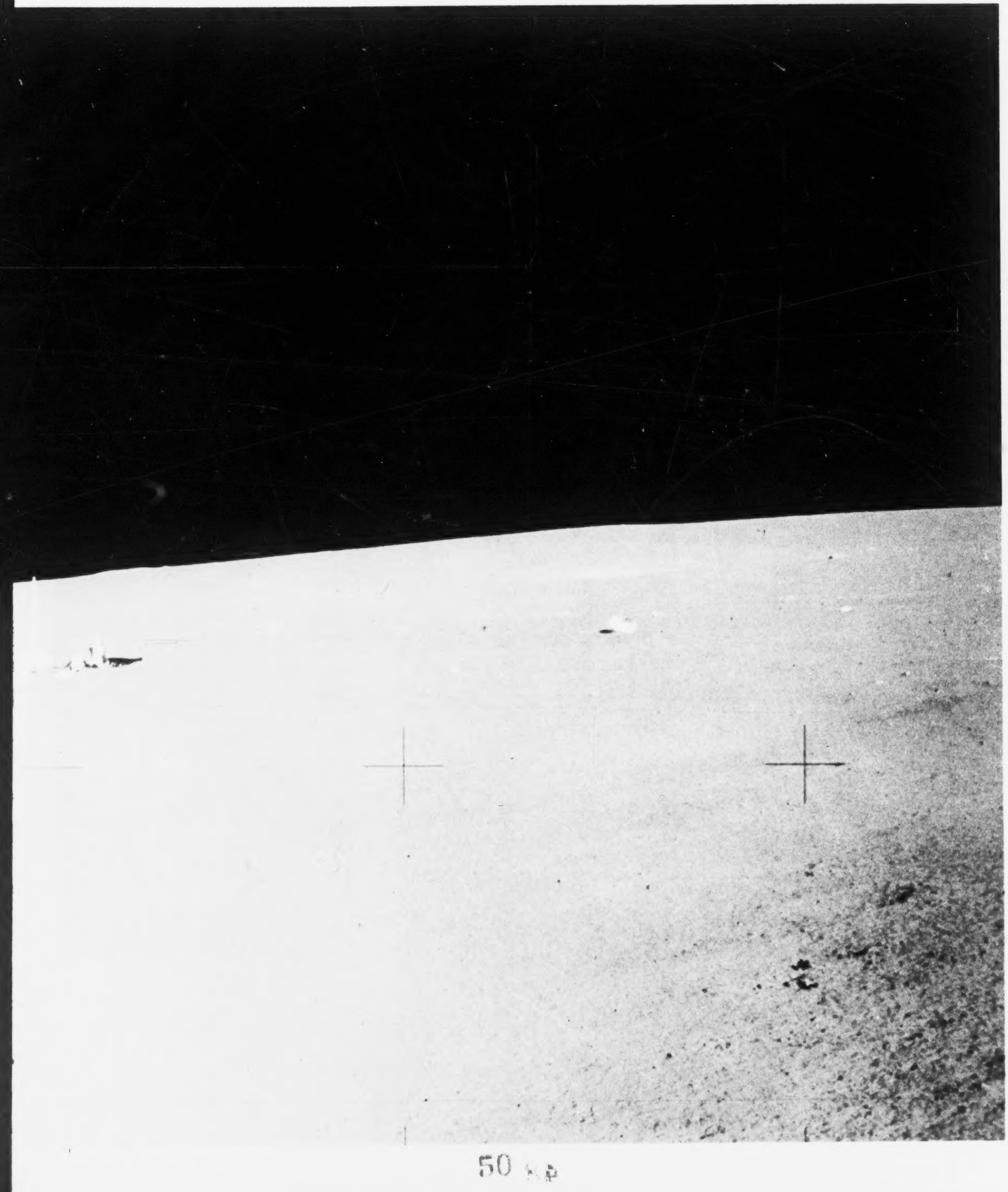

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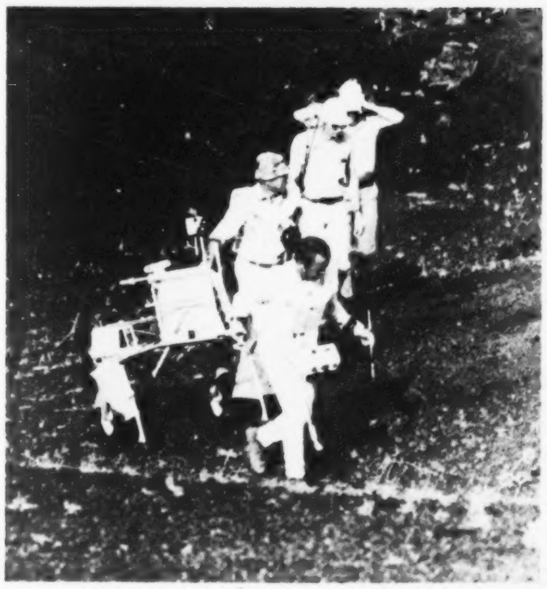
During training in landing craft simulator, Astronauts Shepard (foreground) and Mitchell practice the descent toward the Moon.



On a desert-like strip of land in the United States, Apollo 14 commander Shepard pulls a lunar cart and leads fellow astronauts during preparations for their coming Moon exploration.

transcripts from the various debriefings of the astronauts during the mission and after it, will require weeks or even several months.

The unusual character and liberal amounts of scientific raw material produced by the exploration was due in large part to careful preparation of equipment and the thorough training of the men.

The crew—Shepard, Mitchell and Roosa—was selected in August 1969, just after the first successful manned Moon landing by Apollo 11 in July 1969. Soon thereafter, Apollo 14's launch was tentatively scheduled for October 1970. Its destination was to be the Moon's Littrow region.

But the outcome of Apollo 13 in April 1970 profoundly affected Apollo 14 plans. A board of inquiry into Apollo 13's on-board explosion of an oxygen tank called for several alterations in the Apollo spacecraft. This required a postponement in Apollo 14's launch date to November 1970. The postponement was later extended to January 1971.

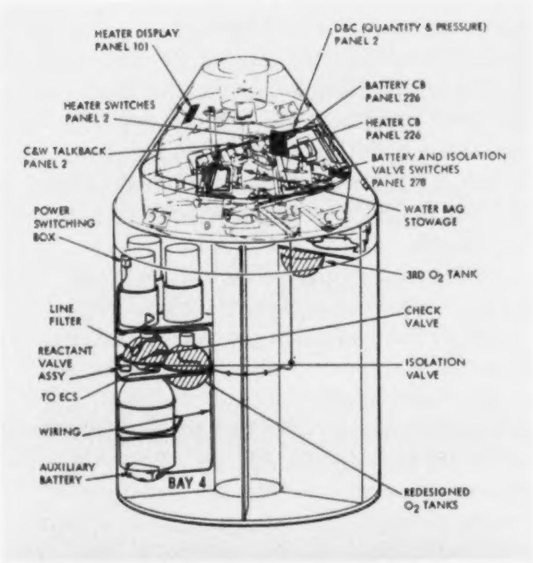
Scientists were regretful that the Apollo 13 mishap had prevented an astronaut landing and exploration of the scientifically titillating Fra Mauro region. They considered it one of the most promising regions on the Moon from a research point of view. Thus, Apollo 14's flight plan was changed. The mission was targeted for Fra Mauro. The first two manned Moon landings—by Apollo 11 and 12—had been in the relatively flat lunar seas or maria. From a pilot's point of view, landings there were easier than in the foothills of the Fra Mauro highlands. But space technology had advanced to the point where a landing in such a rugged area was considered feasible and safe.

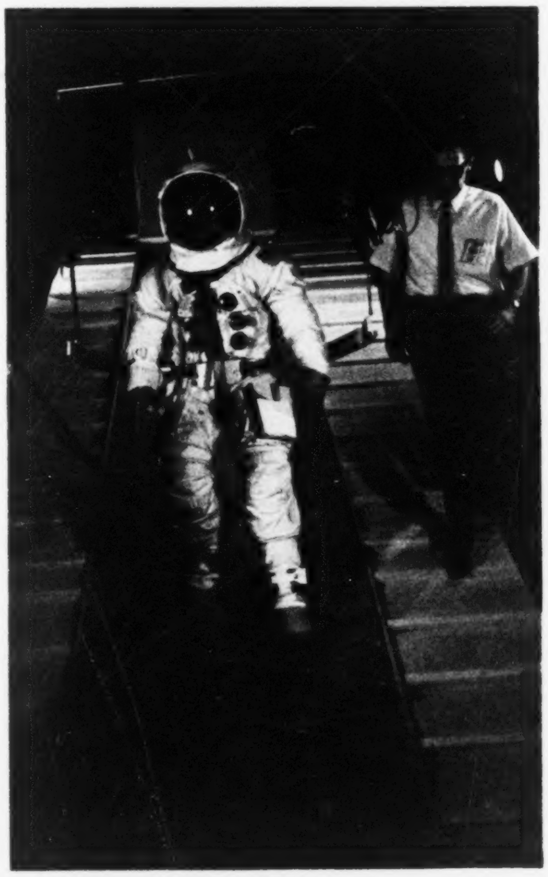
To lessen the possibility of any recurrence of the Apollo 13 explosion, Teflon insulation covering wiring in the service module's oxygen tanks was replaced by less flammable stainless steel sheaths. The experience with the behavior of fluids under zero-G conditions during the earlier Apollo flights showed that fans to stir the oxygen in the tanks were not needed so they were removed. The fans were believed to have been instrumental in causing the explosion. To enhance the craft's ability to return the astronauts safely to Earth, even if any similar mishap should take place, an extra oxygen tank was installed, plus an extra 135-pound (61 kilogram) silver-zinc emergency battery, plus five one-gallon (3.8 liter) bags holding an extra supply of 20 pounds (nine kilograms) of drinking water. These extra facilities would be sufficient to see the astronauts through on a three-day return trip to Earth if the prime supplies should again be destroyed near the Moon. The astronauts used the extra weeks to augment their training. Shepard and Mitchell each spent more than 300 hours practicing walking on the Moon by repeatedly going through their intended lunar surface activities on simulated Moon surfaces and in desert areas which resemble the Moon's terrain. Roosa had nearly 1,000 hours of practice flight in the Apollo command and service module simulator. He rehearsed his flight in Moon orbit while his colleagues would be on the Moon's surface. These and other training activities frequently doubled or exceeded the time spent in similar activities by the earlier Moon landing crews. The Apollo 14 astronauts schooled themselves far more thoroughly than had any of their predecessors in contingency procedures. They practiced alternate methods and rescue techniques for almost every conceivable emergency.

In past flights, crews usually had to follow cram schedules in the last weeks before liftoff to complete all of the desired training programs. The Apollo 14 crew used its extra time wisely, and its preflight schedule was far less congested. At launch time the crew probably was the most rested and relaxed ever sent to the Moon.

An estimated half million persons were in or near the John F. Kennedy Space Center in Florida when the time approached for the launch. Most of them were tourists or residents from the area who gathered outside the Kennedy Space Center. Among the tourists were entire families who came from great distances and pitched tents or lived in house trailers. For them a launch to the Moon was a sight to be remembered and talked about forever. Inside the Center, the number of official visitors was at a record high. Among the special guests were Vice President Agnew, and Their Royal Highnesses, Prince Juan Carlos and Princess Sophia of Spain. A total of 2,355

Changes in Apollo 14 spacecraft to avert a recurrence of the Apollo 13 mishap are indicated in diagram.





Partly suspended, Apollo 14 commander Shepard familiarizes himself with the one-sixth of normal gravity on the Moon by using a low-gravity simulator during training.

epresentatives from newspapers, agazines, radio and television stations ere accredited to cover the flight from ne Kennedy Space Center and the lanned Spacecraft Center. It was the econd largest press contingent for a pace mission, and the number included 02 press representatives from 29 foreign ountries.

As the countdown reached its final inutes, the sky which had been only ightly clouded through the day suddenly ecame heavily overcast and rain began fall at the Cape. Launch officials, beying mission rules laid down after a ghtning bolt struck Apollo 12 nmediately after liftoff and temporarily terfered with its power supply, called a old in the countdown until weather onditions were more favorable. It was the rst launch delay in the Apollo program. ne large digital countdown clock stopped eight minutes and two seconds and ood at that point for 40 minutes before esuming its backward count. The sky as still overcast. But weather experts rcling the launch site in airplanes said ghtning dangers had passed.

Yet a second gust of rain-carrying wind prinkled many of the spectators seconds efore liftoff at 4:03 p.m., Eastern Standard me. Some photographers were still iping the rain drops off their camera nses when the spectacular, but by now miliar, scene of a rocket rising above umes of smoke and fire was reenacted. hirty-six seconds after leaving its launch ad, Apollo 14 disappeared into a layer of ouds and out of view of the spectators. ut the shock waves from its powerful ocket engines shook the viewing stands, nd the rumble from the departing vehicle ould be heard for several minutes.

As is standard procedure, the moment ne spacecraft and rocket cleared the unch tower, responsibility for monitoring ne flight and contact with the crew passed om Kennedy Space Center to Mission ontrol at the Manned Spacecraft Center Houston, Texas. In the abbreviated rgon of astronauts, CAPCOM Haise told ne crew: "14, Houston. Everything looks ood here on the ground." Apollo 14 esponded "Roger." After one and one-alf revolutions around the Earth at an titude of about 100 miles (160 lometers), the third (uppermost) stage the Saturn V rocket, the S–IVB, reignited and boosted the Apollo craft on a trajectory toward the Moon.

Planned flight procedures were identical to those of the earlier Moon landing missions, with the exception of some changes in Moon orbital operations shortly before and after the landing.

Thus, the astronauts now began the so-called "transposition and docking maneuver" which had been successfully performed nine times previously—twice each in the Apollo 9, 10, 11 and 12 missions and once by Apollo 13. But the Apollo 14 crew ran into trouble.

At that stage in the flight, the blunt end of the Apollo mother ship—consisting of the command module in which the astronauts live and work, and the service module containing equipment and supplies—was still attached to a funnel-shaped container holding the landing craft. Attached behind that container was the ring-shaped "instrument unit" with guidance and control equipment, and attached to it was the third rocket stage, also known as the S–IVB.

The task of the astronauts now was to detach the mother ship, and turn it 180 degrees so that the pointed end of the cone-shaped command module would be facing the other units. The panels of the landing craft container would then automatically jettison. Roosa, as command module pilot, would move his craft so that its pointed end would come together with the lunar module. Latches then would close, joining the two craft securely. Roosa would then pull away with the three components of the Apollo craft ready for the Moon approach in their proper configuration—service, command and lunar modules.

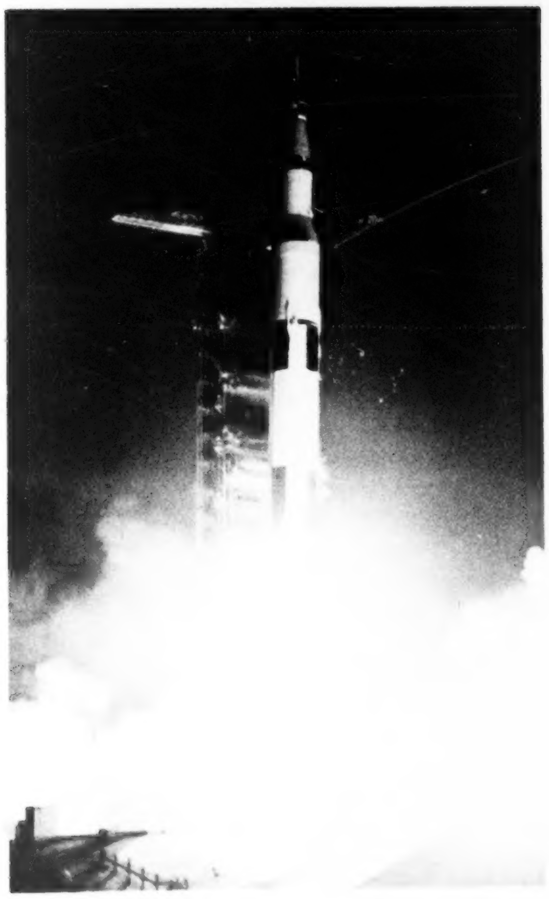
This transposition and docking sequence was to be shown to the world in a 25-minute color telecast from the command module. While millions of television viewers could see the modules closing in on each other, the probe of the command module failed to set off the docking latches. Somehow the two modules failed to mate.

Roosa tried five times to hook the two craft together. In Houston, engineers experimenting with a duplicate of the docking mechanism, attempted to detect the flaw. They also closely watched the telecast from space, hoping to spot the cause of the problem. About two hours

With help from technicians, Apollo 14 commander Shepard dons his space suit during countdown on January 31, 1971. Below, launch personnel at Kennedy Space Center monitor liftoff preparations in launch control room.

In Mission Control at the Manned Spacecraft Center, Houston, Texas, personnel watch telecasts from the Moon-bound Apollo 14 as the crew attempts the docking maneuver six times before succeeding.

Spectators watch Apollo 14 disappear into low cloud layers. Rain delayed the launch 40 minutes.



The Moon is the next stop for Apollo 14 as it rises off launch pad 39A at 4:03 p.m., Eastern Standard Time, Sunday, January 31, 1971.

While Apollo 14 experienced docking difficulties, a solution was sought at Mission Control with a duplicate docking mechanism by (from left) Astronaut Eugene A. Cernan, Assistant Flight Director Charles S. Harlan and Astronaut John W. Young.

had passed by the time Roosa made a sixth attempt at docking, a procedure which ordinarily takes less than one-half hour. This time, on the advice of the Houston engineers, he closed in slowly, then fired his craft's small thrusters, giving it a sudden forward jolt. At the same time, he retracted the probe. As the docking collar of his craft met the matching component of the landing craft, the latches finally sprang into place.

This solved the problem for the moment, but left the mission in a state of suspense. Docking would have to be done once more, at a critical time. Later, when Shepard and Mitchell would return from the Moon in the Antares, they and Roosa would once again have to connect the landing craft and the mother ship.

Should the docking mechanism then fail to work, Shepard and Mitchell could not reenter the main spacecraft through the interior tunnel between the two modules in the normal manner. However, in such an emergency, they could leave Antares through a hatch, "walk" through space, and then enter Kitty Hawk through its hatch. Such a transfer, however, has never been tried in Moon orbit, though astronauts have "walked" through space between vehicles orbiting the Earth during the two-man Gemini flights in 1965 and 1966.

During the three and one-half-day journey toward the Moon, the Apollo 14 crew was often so uncommunicative that CAPCOMs at Mission Control sometimes started talking because, as one of them phrased it, he "just wanted to see if you all were still around."

But it could hardly have been boredom that kept the crew so quiet. Shepard and Mitchell entered Antares through the interior tunnel to power it up and give it a final check before it would have to begin its crucial task of landing them on the Moon and bringing them back to Kitty Hawk. During that test, an indicator on a monitor panel at Mission Control showed a reading for one of Antares' batteries to be three-tenths of a volt below normal. The battery was one of two in Antares' ascent stage, the upper portion, in which the astronauts lift themselves from the Moon's surface to return to Kitty Hawk after completing their Moon walks. Though one battery is sufficient for that job, Mission Control would not have given a go-ahead for a Moon landing without the backup battery also functioning properly. Experts feared a leakage might have developed in Antares' complex electrical circuitry. While the astronauts continued their flight schedule with a planned 10-hour rest and sleep period, Mission Control assessed the situation, and decided not to awaken the crew. But after the rest period, Mitchell was ordered to return into Antares for an on-the-scene battery check, and he found the battery showed no further deterioration. It would be able to provide the required power.

In all previous manned lunar flights, the main Apollo craft has come no closer than 70 miles (112 kilometers) to the Moon's surface. At that altitude, the Moon landing craft detached itself from the main spacecraft to begin its descent to its lunar landing site.

A different approach was made desirable for Apollo 14 by the hilly terrain at the intended Fra Mauro landing site. During their first passage on the far side of the Moon, the astronauts fired their craft's main engine, the service propulsion system (SPS) for six minutes and 12 seconds to slow their craft sufficiently so that it inserted itself into an elliptical Moon orbit 70 miles (112 kilometers) at its lowest point (pericynthion) and about 193 miles (310 kilometers) at its highest altitude (apocynthion). This was identical to the procedure used on previous missions. After two such orbits, a short burst by the main engine decelerated the craft still more to lower its orbital path to as close as 50,000 feet (15 kilometers) above the Moon at the lowest point and about 70 miles (112 kilometers) at the highest. That orbital change-over maneuver is known as "descent orbit insertion" or DOI, and it brought the Apollo main craft—the command and service modules—closer to the Moon than it had ever been. In that lower orbit, Apollo 14 was clearing the highest peaks of the Moon's mountain ranges by only about seven miles (11 kilometers). Though Mitchell later said that his first look at the Moon from that height was for him one of the emotionally most touching experiences of the journey, Roosa seemed less impressed.

Many months of training in simulators had accustomed Roosa to the scene so thoroughly that the real thing appeared quite familiar.

"I'm going to back off from you," said Astronaut Roosa as he pulled Kitty Hawk away from Antares. Then he added "And we're free" as the craft separated. He took this photograph of Antares before it began its descent toward the Moon.

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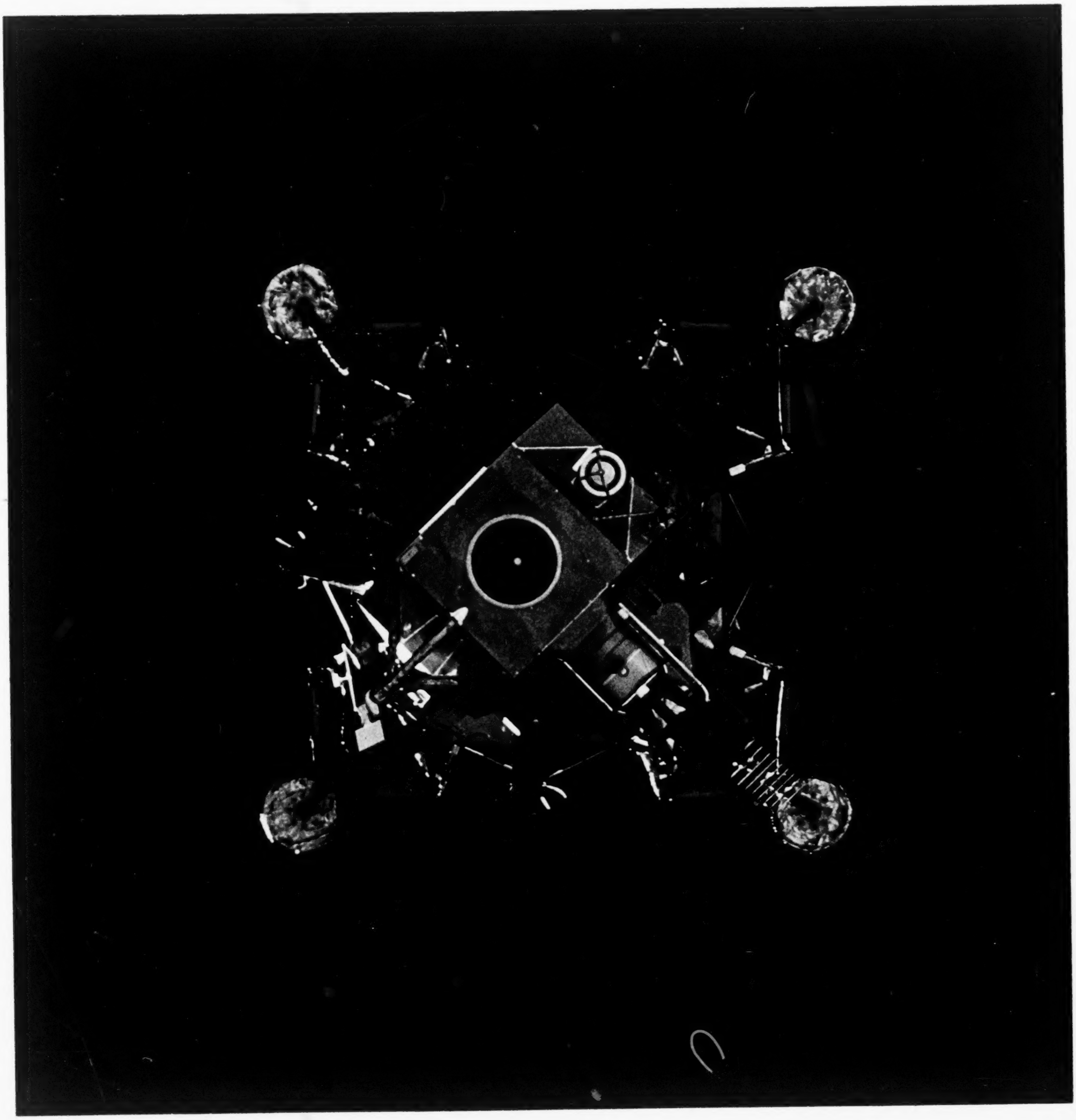

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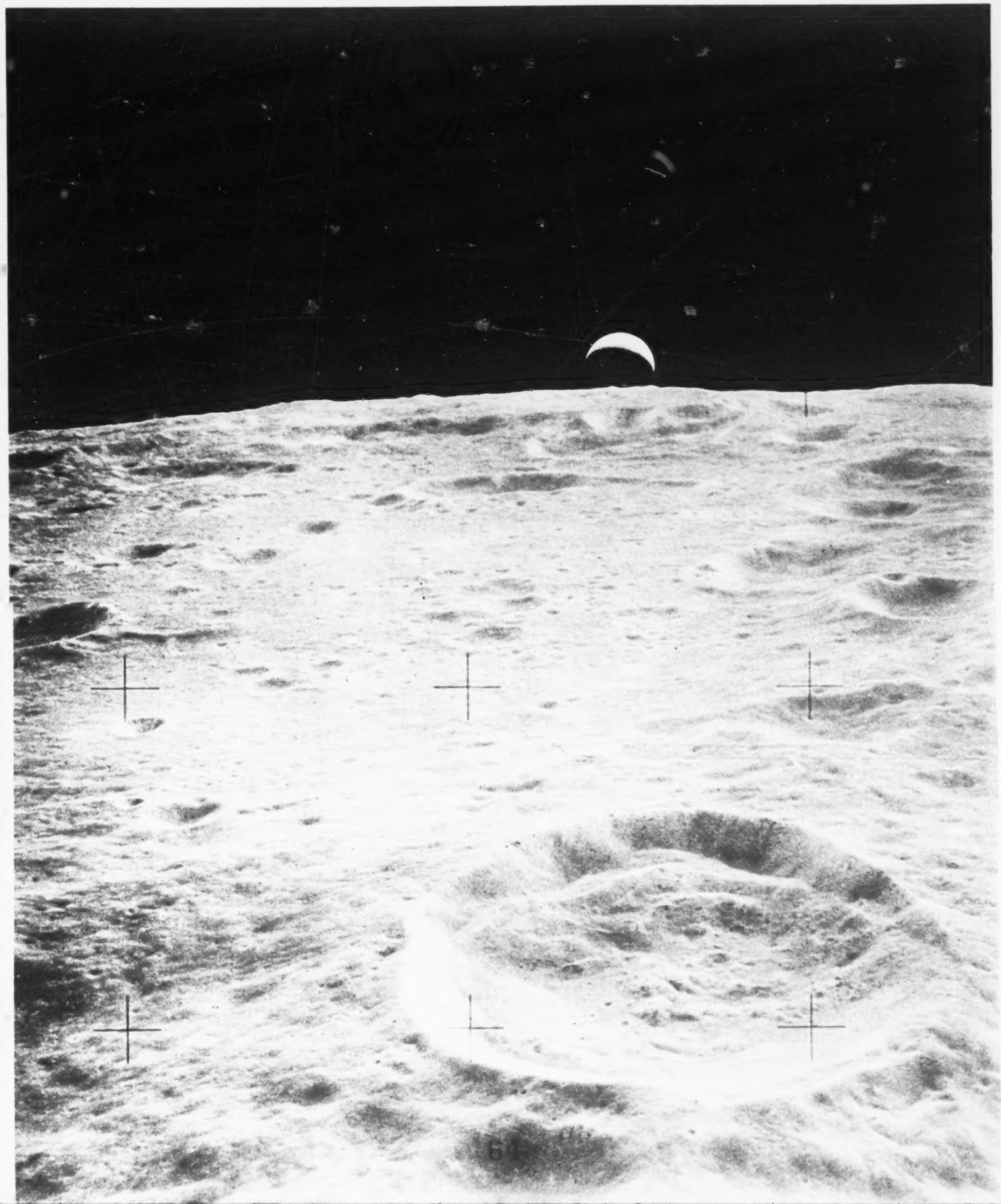
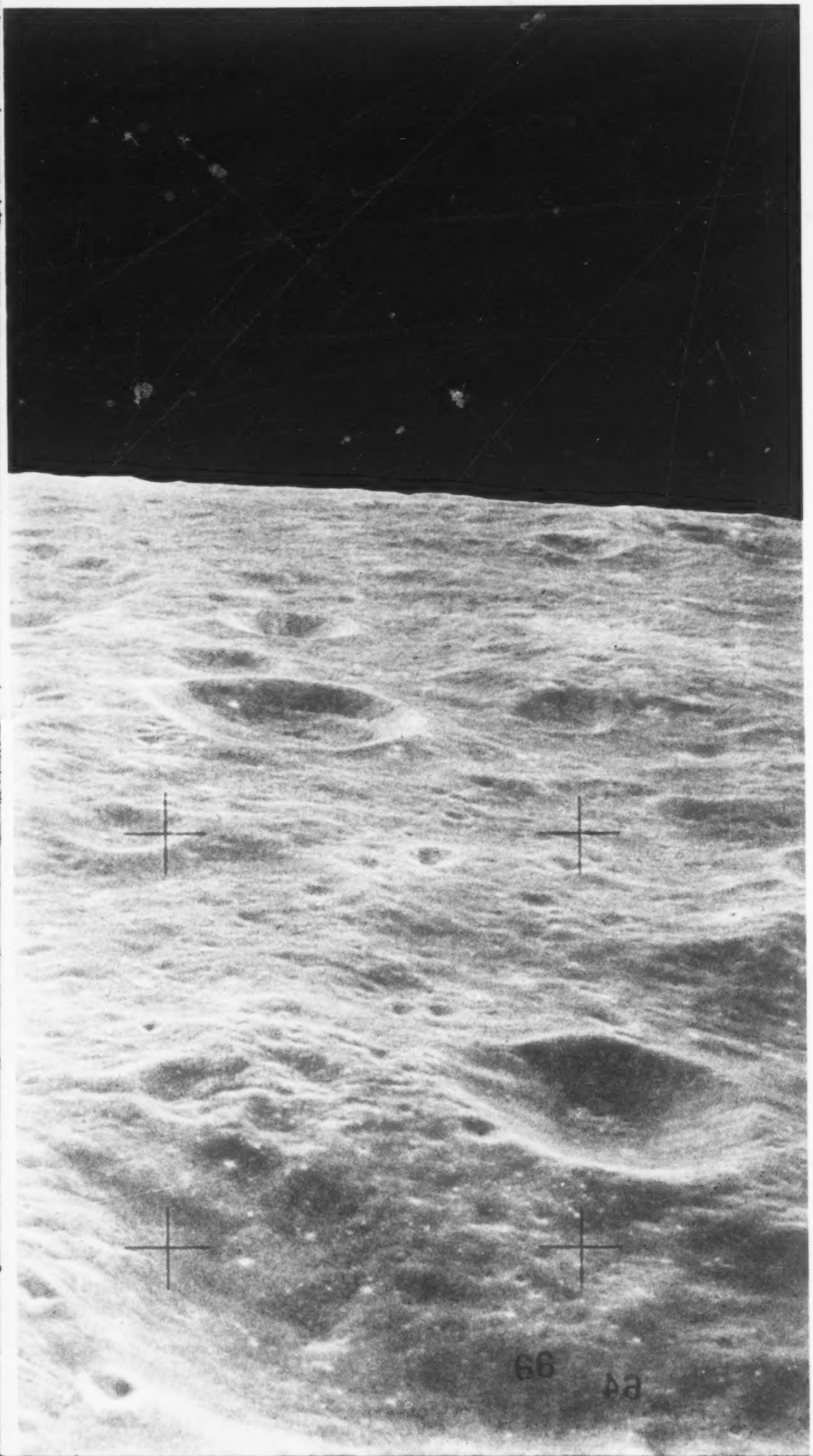
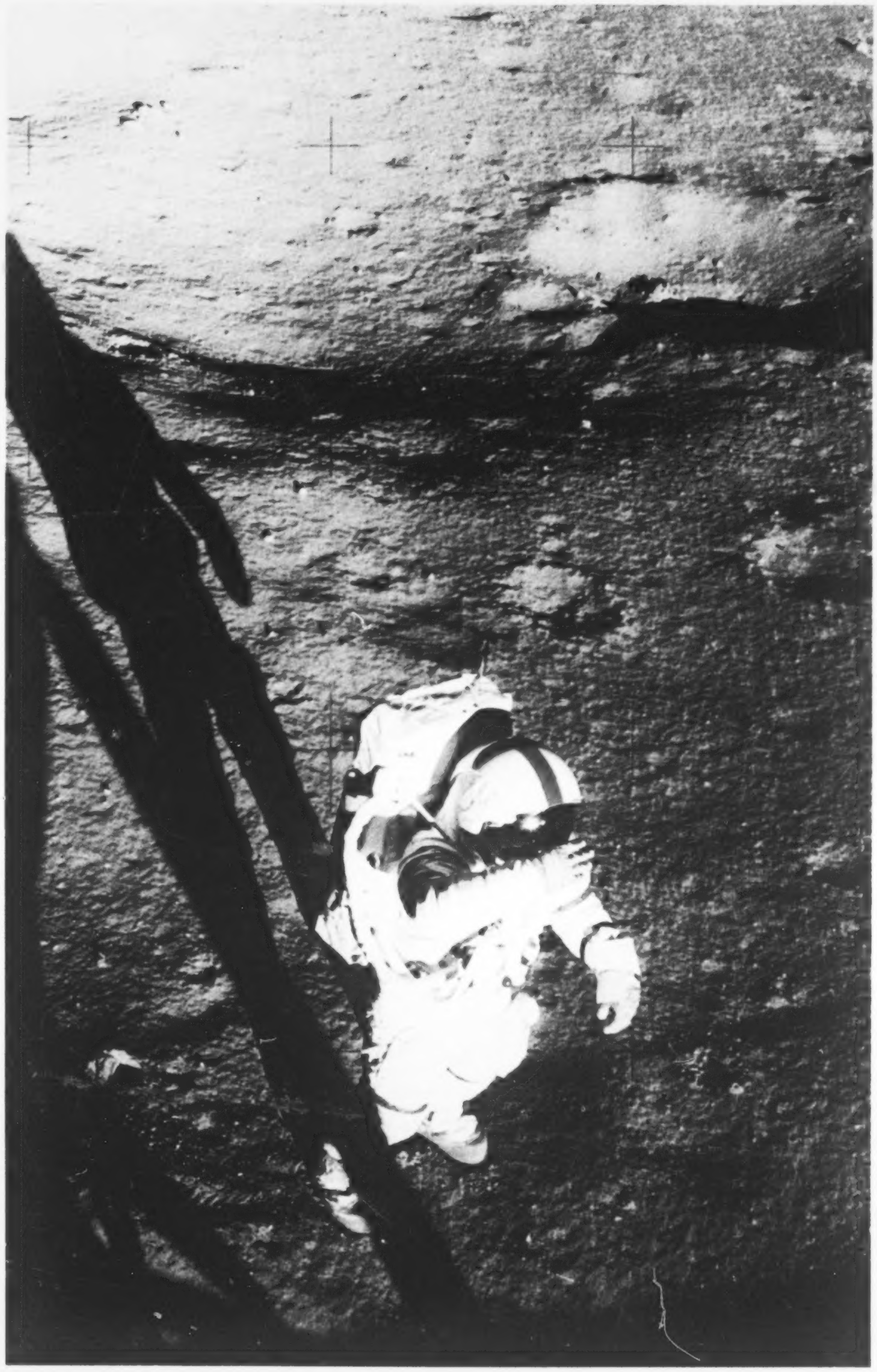


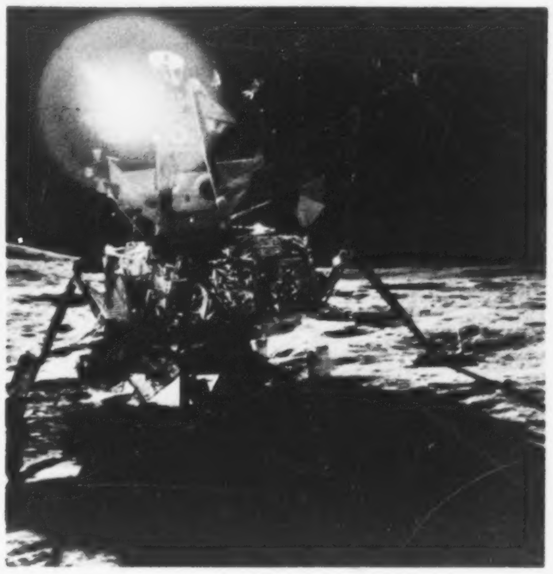
"It's a beautiful day in the land of Fra Mauro," said Apollo 14 commander Shepard. Beyond the crater-pocked horizon rises Earth, a thin crescent against the backdrop of a velvety sky.



From lunar orbit, the Apollo 14 crew photographed these Moon scenes.



"I'm moving around, getting familiar with the surface," said Shepard moments after he stepped on the Moon while Mitchell took this photo from the landing craft.



In the dawn of the lunar day, Antares cast long shadows and reflected the Sun in a way that appeared to the astronauts as a circular flare which they described as "jewel-like."

"You're not gonna believe this," he called to Mission Control as he first beheld the lunar landscape below him. "But it looks just like the map."

By that time, through midcourse corrections made on the way to the Moon, Apollo 14 had regained the 40 minutes lost by the launch delay, and the flight was precisely on the time schedule originally laid out for it.

By bringing the spacecraft to this lower orbit and letting Antares proceed from there toward a landing, fuel was saved in Antares. Thus, Antares gained about 14 seconds of extra operating capacity. Small as this additional capability may seem, it allowed Shepard to hover that much longer above the Moon and, thus, gave him more time to select the most favorable touchdown point in the target area. Also, the procedure permitted accumulation of more spacecraft tracking data before the landing.

While the spacecraft remained in that orbit, the astronauts ate and slept. Then Shepard and Mitchell crawled once again through the tunnel into Antares. Roosa remained alone in Kitty Hawk. Shepard and Mitchell powered up Antares and detached it from Kitty Hawk in preparation for the impending Moon landing – only to discover a problem. Antares' guidance computer was receiving a warning signal from the craft's abort mechanism. The computer was programmed to react automatically to such a signal by initiating a sequence that would abort the landing shortly after the descent engine began firing. In this abort sequence, the spacecraft would be boosted back into a Moon orbit for reunion with Kitty Hawk instead of toward a Moon landing.

The defect was traced to the faulty switch. With less than two and one-half hours remaining before the planned engine ignition, Mission Control hastily called for help from the computer's designers at the Massachusetts Institute of Technology at Cambridge, Massachusetts. There, engineers and technicians were summoned from their homes to their offices. Together, they worked out a solution to circumvent the faulty switch. This required that Mitchell punch a long series of numbers into the computer's keyboard inside Antares four minutes before engine ignition. There was little time to lose. Technicians verified the proposed action on ground simulators. Then the numbers were read to Mitchell from Mission Control. He managed to complete the entries within the critical period. If he had missed, the astronauts would have had to keep Antares in Moon orbit for another two-hour revolution and then start anew to make the necessary adjustments. Twenty-six seconds after engine ignition, Shepard took manual control of the engine throttle to override the automatic computer program. Mitchell, as directed by Mission Control, entered three more sets of instructions into the guidance computer. This straightened out that problem.

But as Antares swooped closer and closer to the Moon, the on-board landing radar, which controls the descent rate by continuously measuring the decreasing altitude, failed to lock on to the lunar surface. This was to have begun at an altitude of about 30,000 feet (9,000 meters). Mission Control instructed Mitchell to keep flicking a circuit breaker on and off. That did not seem to help until the altitude had shrunk to 22,713 feet (6,923 meters). The radar finally sprang to life. Mitchell's sigh of relief could be heard around the Earth. "Whew," he said. "That was close."

These incidents were among several which illustrated the advantage of manned spacecraft. Men can monitor and supersede machine decisions.

The rest of the descent and landing could not have been better. Antares came to rest on an 8° slope. The slope's angle was too small to cause any anxiety over the craft's possibly toppling over, or to make its takeoff hazardous.

Meanwhile, from his lofty perch in Kitty Hawk, Roosa could clearly see the location of Antares.

"It just showed up as a white spot, obviously something foreign to the lunar surface reflecting light," recalled Roosa later. "The first day I tracked it while the Sun angle was still pretty low and you could see the shadow and the reflection . . . You couldn't see a shape of the LM as such, but with no doubt, the LM was there." He said on the next day, when the Sun was higher in the Moon's sky, the shadow diminished, but he could see a glint reflecting also from the ALSEP.

Shepard and Mitchell donned their Moon suits and were nearly ready to leave Antares for their first steps in this strange world, when Shepard noticed that his

Beside the U.S. flag at Fra Mauro Base, Shepard is surrounded by shadows. The one in front is from Mitchell who took this picture. The shadow at left is from Antares, and the one at right from the umbrella-like S-band antenna.

radio—the communications system built into his Moon helmet and backpack for conversing with Mission Control and Mitchell while walking on the Moon—was not operating properly.

In consultation with engineers at Mission Control, Shepard and Mitchell tracked down that problem to a circuit breaker that had inadvertently been left in the wrong position.

Starting later than scheduled on the first Moon walk, Shepard and Mitchell encountered other unexpected problems that caused them to fall still farther behind their "timeline." The S-band antenna failed to stand properly. When unfolded, it resembles a large lawn umbrella and it is used to improve transmissions of television, voice and data. Moon dust proved annoying too as it clung to the astronauts' clothes and gear. While Mitchell was setting up ALSEP, Moon dust apparently got into and clogged a fastener of the Suprathermal Ion Detector. The Cold Cathode Ionization Gauge repeatedly fell over as Mitchell tried to steady it on the uneven lunar topography.

Yet the astronauts remained in high spirits and in excellent physical condition. Their oxygen and cooling fluid supplies remained ample and above any danger level. Thus, the astronauts were able to complete all of their assigned tasks before they crawled back into Antares.

They ate and rested, then donned their Moon outfits again. Eager to continue their explorations, they began their second Moon walk period two hours earlier than scheduled. According to the flight plan, that second Moon walk was to be devoted almost entirely to the long geological traverse to Cone Crater. The rugged terrain slowed the men, and again they fell behind their schedule. Nevertheless, by skipping two planned stops, Shepard and Mitchell were able to complete all assigned tasks for the second Moon walk except one. They fell short of reaching Cone Crater's rim.

During their return to Moon orbit, Shepard and Mitchell used a new time and fuel-saving procedure for achieving rendezvous (formation flight) and subsequent docking between Antares and Kitty Hawk. That technique, known as a "first-orbit rendezvous," was developed and practiced during the two-man series of Gemini flights in 1965 and 1966. But the technique had not been used on Moon missions until Apollo 14 because of its complexity.

The first orbit rendezvous technique brought Antares and Kitty Hawk together in about two hours instead of the usual four or five hours required for the maneuver. This time, docking occurred normally on the first try. Experts at Mission Control said they suspect some contamination, possibly ice that formed on the spacecraft, might have been the cause of the earlier docking problem. They said the cause may never be determined, but whatever it was, it apparently had disappeared.

After crawling through the connecting tunnel for the last time and transferring the containers with their treasured Moon rocks and various equipment, the astronauts bade farewell to their loyal Antares and jettisoned it. It was Saturday, February 6. The three men, now back together in Kitty Hawk, ignited their main engine to speed the craft out of Moon orbit and onto a path back toward Earth.

On Sunday evening, February 7, in the next-to-last of their eight color telecasts from space, the astronauts conducted a series of four engineering demonstrations. They were designed to test the behavior of fluids and gases in zero-gravity. The results of the tests could ultimately lead to the manufacture of goods which cannot be produced in the Earth's gravity. Thus, the Apollo 14 in-flight demonstrations could turn out to be primitive forerunners of factories inside large orbiting space stations, in which valuable products stamped "made in space" could be manufactured for use on Earth.

One of the demonstrations tested the casting of metals in weightlessness. When molten metals are mixed on Earth, the heavier components of the mixture tend to settle toward the bottom. The demonstration was aimed at showing whether, under the zero-gravity conditions of space, it may be possible to cast almost any mixture of metals perfectly evenly. If this should prove to be possible, new alloys could eventually be formulated in space—some perhaps with the strength of steel, yet with the weight of cork—that would be impossible to produce on Earth where weightlessness can be achieved for only a few seconds at a time.

Mitchell adjusts the color television camera. It allowed millions of viewers throughout the world to share the exploration with astronauts 250,000 miles (400,000 kilometers) away.

An eerie glow of sunlight during the lunar morning symbolizes the mysteries of the universe Apollo 14 sought to unravel. Astronauts deliberately landed while the Sun was low in sky so that rocks, craters and other surface features were readily recognizable through long shadows.

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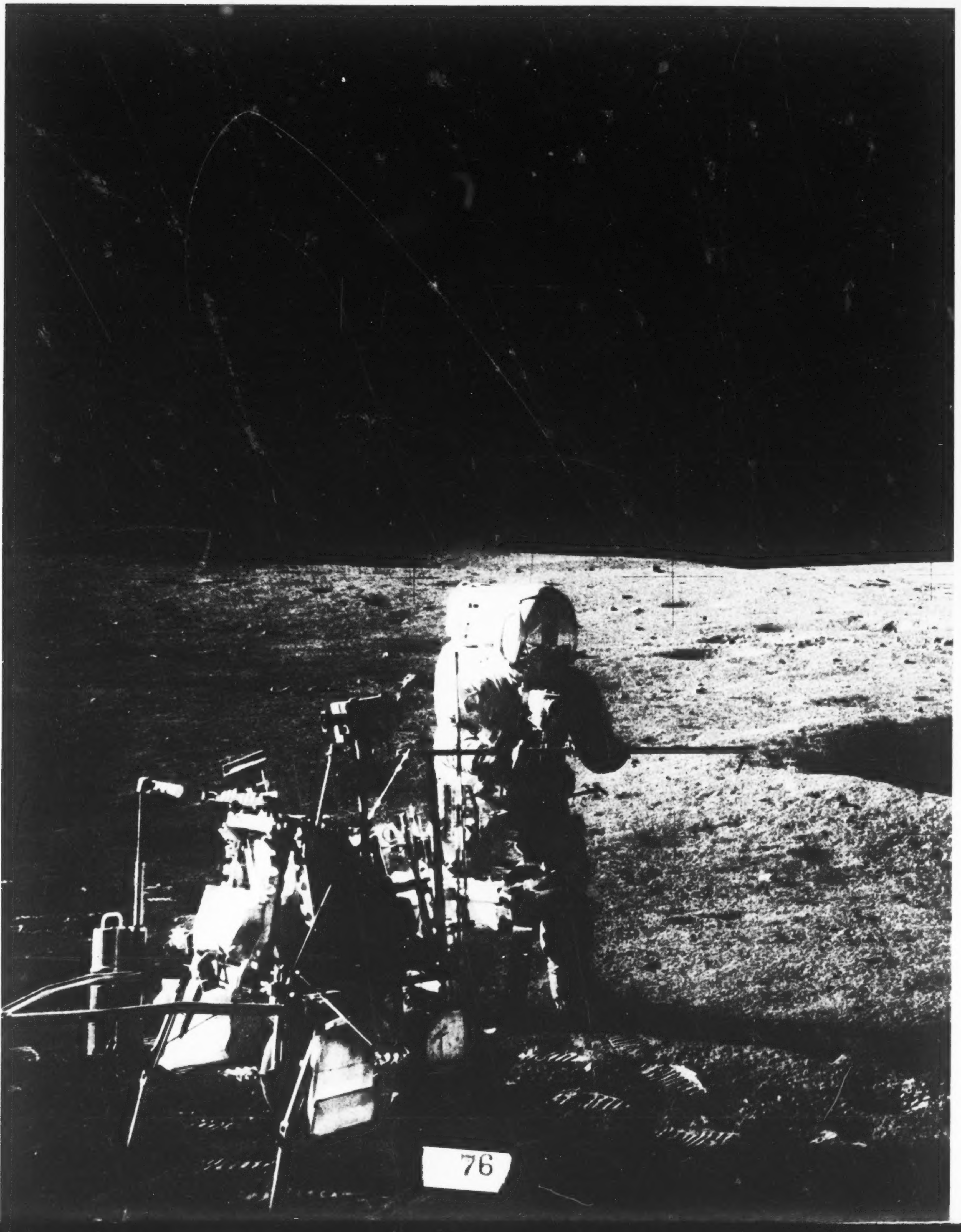
Removing and assembling a tool from the pull-cart, Shepard prepares a geological experiment. He and Mitchell made man's first visit to the Moon since the Apollo 12 astronauts were there in November 1969.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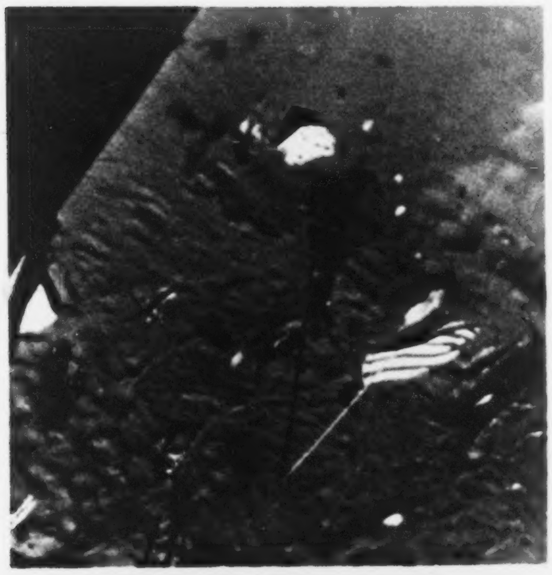


During liftoff from the Moon, exhaust of Antares' rocket engine causes the flag to flutter and loose pieces of heat shielding gold foil to fly.

Kitty Hawk steered by Roosa looked like this to Shepard and Mitchell as they approached in Antares for a reunion in Moon orbit.

The various mixtures which the astronauts tested were contained in 18 sealed capsules which the astronauts heated and then allowed to cool. After heating, the astronauts shook and turned some of the capsules several times. Some of the specimens included crystal and fiber-strengthened materials. The outcome of the experiments are now being determined by scientists and engineers who are examining the capsule contents in their laboratories.

A similar demonstration on heat flow and convection under zero-gravity conditions involved different colored liquids representing various gases. On Earth, hot air (or other gases) rise above cooler air because heating causes a gas to become less dense and, therefore, lighter. The demonstration was aimed at finding out whether heating in space takes place evenly and uniformly.

Still another demonstration dealt with a process known as electrophoretic separation. It is widely used to separate biological components in the manufacture of vaccines and medicines. A test was conducted to see whether such separations in space would be useful in producing medicines and vaccines faster and with greater purity.

The final demonstration pertained to the transfer of fluids between containers—such as fuels from one tank to another—in weightlessness. Because liquids tend to stay close to container walls in weightlessness, drawing them out for transfer to an engine, or for other use, presents problems unknown under normal conditions on Earth. The astronauts used a small pump to transfer small quantities of liquids between containers in which various configurations of baffles were tested for their influence on the liquids' distribution inside the tanks. The demonstration could influence designs of large semi-permanent space stations of the future. All four of the experiments are expected to form the basis of further in-space tests, including some in Skylab, the prototype space station that is to be launched early in 1973.

Roosa, who had been explaining the demonstrations during the telecast, was ready to end the program. "I guess that's about all from our zero-gravity lab on Apollo 14," he said. Then he added what could become a prophetic declaration. "We hope this is the beginning of bigger and better things in the way of space manufacturing processes, and I believe Al has got some words here."

Shepard took over to conclude the program with a serious statement about the value of space exploration and a plea for world peace. "I just wanted to say a couple of words before we signed off tonight," Shepard began. "What we've been talking about among the three of us when we were setting up these experiments was the contribution this can make immediately and directly to American lives and the lives of people around the world. For example, if, specifically, these manufacturing processes turned out to be better in the space environment, or the vaccines which are proposed to be developed in a weightless condition can be used effectively, then this type of an operation in Skylab can become immediately beneficial to the people of the United States and the people of the world.

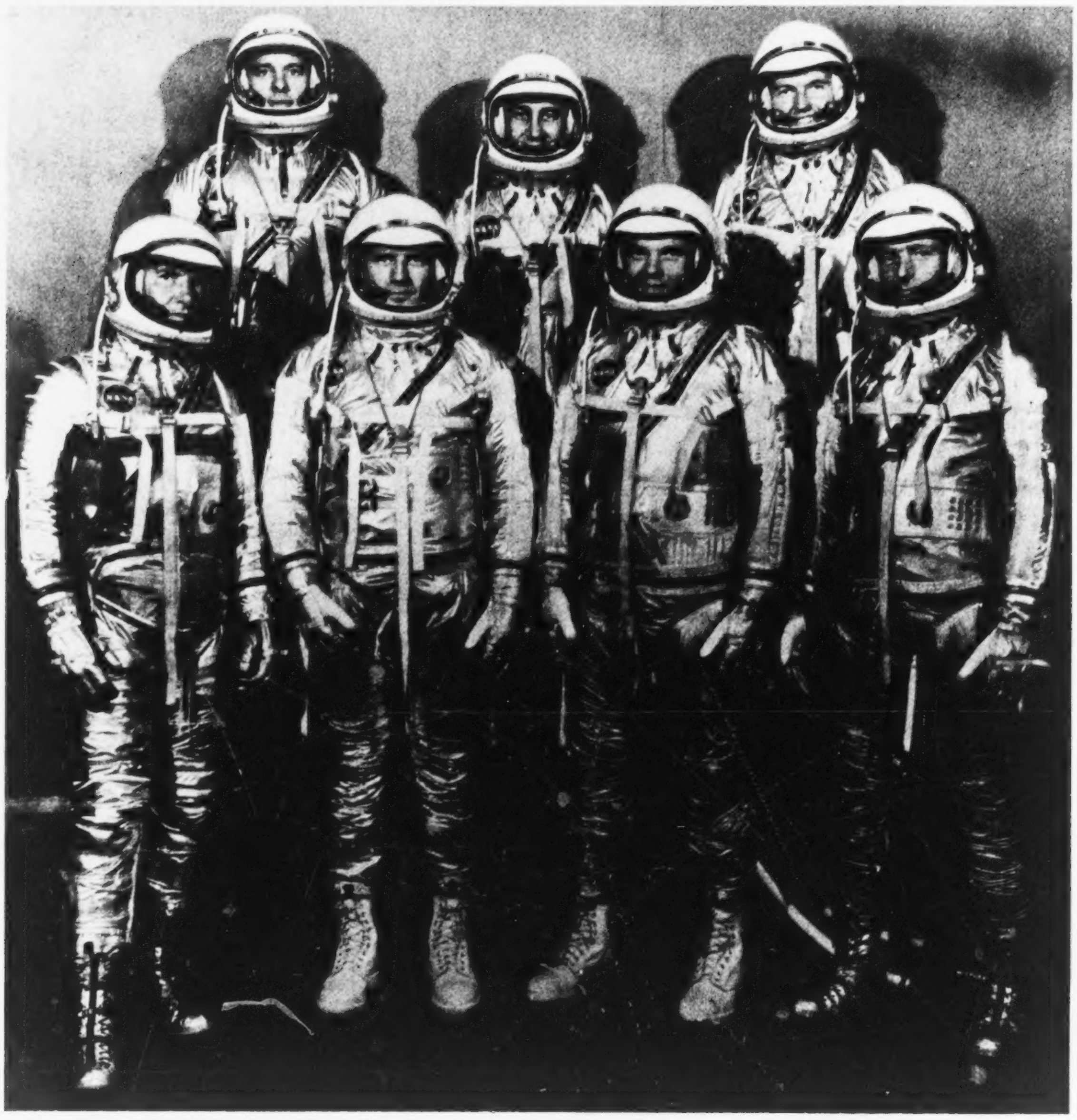
"As a matter of fact, one of the things we're talking about in connection with the tremendous achievements of the space program so far are its contributions particularly in the field of communications. For example, right now, I'm sure this broadcast is going directly overseas to millions of people who are seeing it in their homes through satellites, and I think many people have said that this improvement in communication through the space satellite will certainly go a long way in solving the problems of the world, problems of understanding between peoples of different countries.

"We are reminded, however, as we look at that shimmering crescent which is the Earth, on our way back, that there is still fighting going on. It is our wish tonight that we can in some way contribute through our efforts in the space program to promote a better understanding of peace throughout the world, and help rectify these situations which still exist."

"With that thought, for Ed and Stu and myself, I will say goodnight to you from Apollo 14."

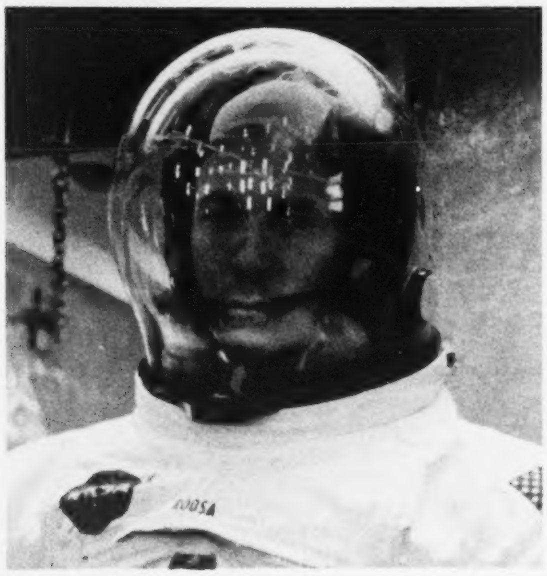
For Shepard and his crew, the flight of Apollo 14 was a colossal personal triumph. For all three of the men the flight fulfills a nearly life-long ambition. Shepard is the senior in age and length of service in the cadre of 49 active astronauts now in training in the United States. He was the first to fly in space of the "Original

Apollo 14 Commander Alan B. Shepard, Jr. (back row, left) is seen in this 1959 photo of the "Original Seven" astronauts.



Apollo 14 Commander Alan B. Shepard, Jr.

Lunar Module Pilot Edgar D. Mitchell



Command Module Pilot Stuart A. Roosa

Seven" – the seven men who in April 1959 were chosen for training for space flight. Now, he has also become the last of that original group to fly in space. The others are no longer in the space program, except Donald K. (Deke) Slayton, who holds a key administrative job and is not in space flight training.

One of the tallest of the astronauts (five feet, 11 inches – 180 centimeters), Shepard, a native of East Derry, New Hampshire, represents his family's eighth generation in that state. After his first spaceflight, Shepard was to be assigned as Commander of a two-man Gemini mission, but he became ill with an ear infection, known as Meniere's Syndrome, which caused him dizziness, nausea and other discomforts. The condition was so severe that physicians refused to certify the former test pilot even for flying convential aircraft unless accompanied by another pilot. He accepted a desk job, coordinating activities of other astronauts. By May, 1968, Shepard was nearly deaf in his left ear, in which he had a constant humming sound. He underwent surgery which inserted a rubber tube into the inner ear to relieve fluid pressure. The operation restored his health, and he was reinstated to astronaut flight status in 1969.

It was not difficult to grasp the emotional overtones of Shepard's first words after he lowered his left leg from the landing craft's footpad and his boot touched the Moon. "It's been a long way," he said. "But, we're here."

Mitchell, who earned a Ph.D. degree in aeronautics and astronautics at Massachusetts Institute of Technology, and Roosa, who, like his colleagues, is a former test pilot, made their first space flight on Apollo 14. Both have been in astronaut training since April 1966.

On their last full day in space, Monday, February 8, the Apollo 14 crew reviewed and assessed the epic flight in a televised press conference from the spacecraft while it was still slightly more than 100,000 miles (160,000 kilometers) from Earth and speeding toward Earth at a rate of 3,681 miles (5,924 kilometers) an hour.

The astronauts appeared relaxed and sounded cheerful and pleased about their journey's accomplishments. The men took turns answering questions posed by newsmen who had been following the flight at the Manned Spacecraft Center in Houston, Texas. The questions were read to the Apollo 14 crew by astronaut Gordon Fullerton acting as CAPCOM.

Shepard and Mitchell said, in answer to a question, that they believe that on the second of their two historic Moon walks they were 100 to 150 yards (90 to 135 meters) from the rim of Cone Crater.

(Later, experts from the U.S. Geological Survey determined in their analysis of the Moon walk that the men had probably come to within 25 to 50 meters – 82 to 164 feet – of the rim.)

"Given another 30 or 40 minutes, I think we could have reached the top of Cone Crater, covered all of our objectives and gotten back in good fashion," said Mitchell.

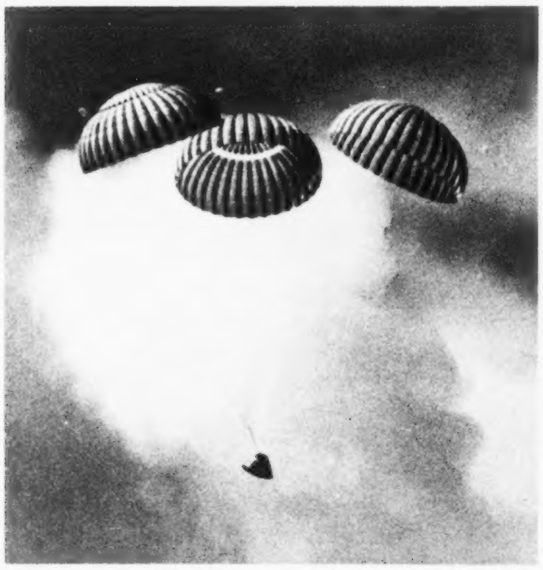
Shepard broke in. "Well, let me add one thing here," he said. "I think if we had wanted to reach the top of the crater and do nothing else, we could have done that within the allotted time period. But I think that this method in which we reverted to collecting rocks from a point not quite near the top of the crater provided a lot more geologically and gave us a better cross section of the rocks in that area. To us it was just a matter of working against the clock. I think we had the capability to go longer from the standpoint of fatigue – I don't believe we were disoriented or lost at any time at all."

Roosa, also in answer to a question, said that despite a broken camera, he believes he was able to obtain good stereo photography of candidate landing sites for future Apollo missions and of other areas of particular scientific interest on the Moon.

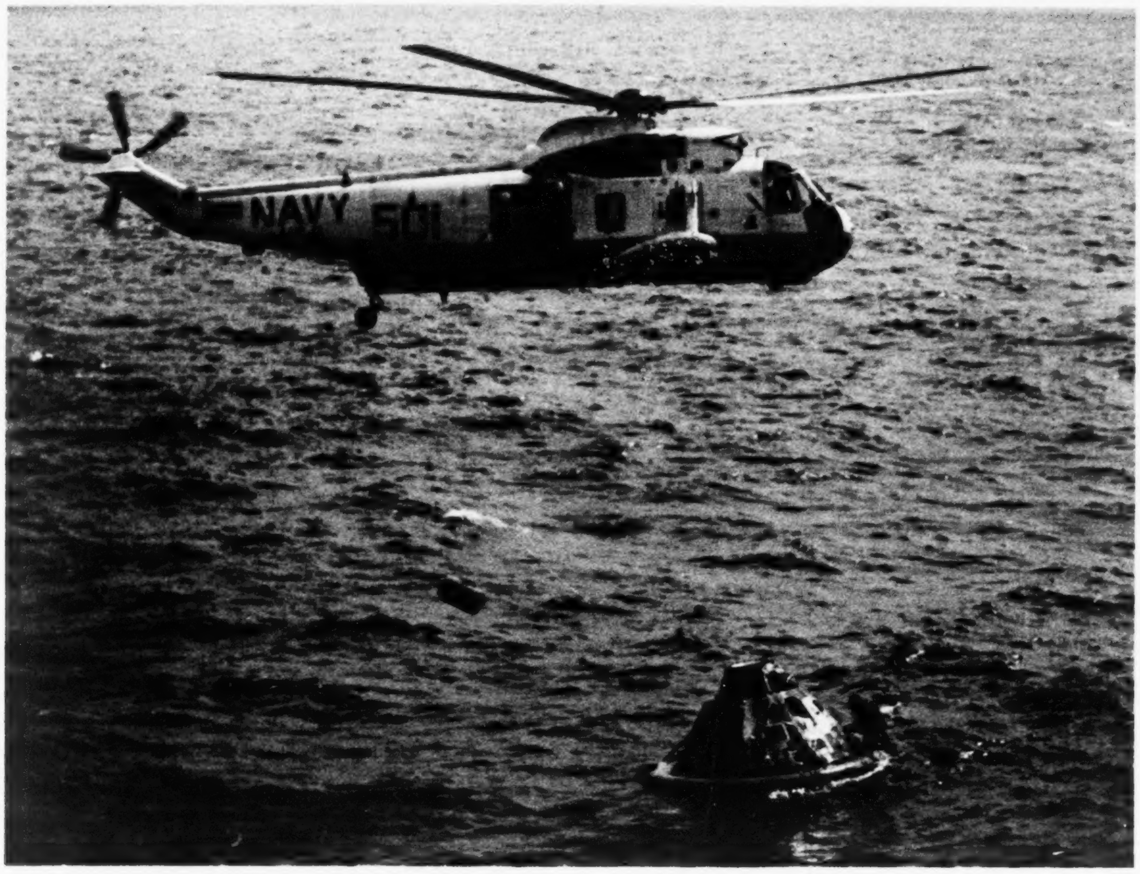
It was history's second in-space press conference. The first had been held by the Apollo 12 astronauts in November 1969 while they were on their way back to Earth after history's second manned Moon landing. The Apollo 13 crew never got around to their planned in-flight press conference. The men were kept too busy during the return tending to their severely damaged craft after the explosion that prevented a Moon landing attempt.

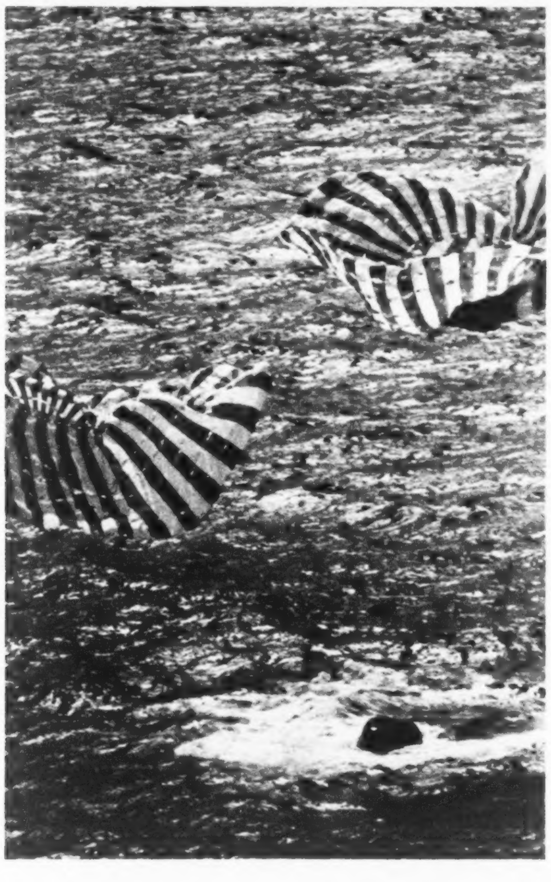
On Tuesday, February 9, the Apollo 14 spacecraft arrived in the vicinity of the Earth. After jettisoning the supply and equipment-carrying service module, which was now no longer needed, the crew

Plunging through the atmosphere after separating from equipment-carrying service module, command module is slowed by parachutes billowing above it.



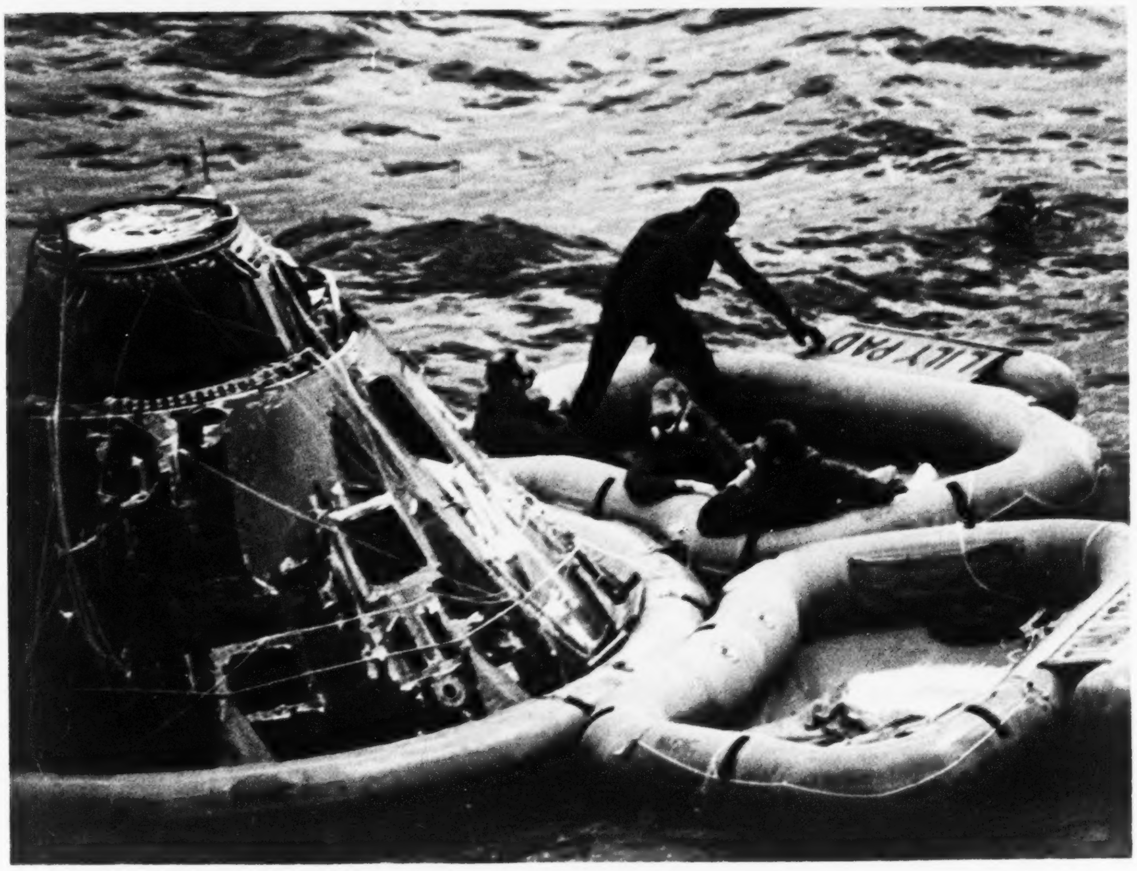
A folded raft is thrown from a hovering helicopter to a frogman attaching the flotation collar around the command module. Astronauts are still inside.





Orange and white parachutes collapse as the craft hits the water. Thus, the journey of nine days and two minutes ended at 4:05 p.m., Eastern Standard Time, Tuesday, February 9, 1971.

Hatch is open and an astronaut emerges.



In raft, Apollo 14 crew and a frogman of the recovery team await helicopter pickup.

aboard the command module reentered the atmosphere. On the deck of the helicopter-carrying recovery ship, the USS New Orleans, a color television camera caught sight of the spacecraft the moment a drogue chute began to slow its plunge through the atmosphere. Then, the trio of main parachutes deployed.

On television screens, the command module could be seen swaying below the orange and white chutes against a backdrop of a clear-blue sky dotted only by a few scattered thin white clouds. The craft splashed down on the Pacific Ocean 900 miles (1,450 kilometers) south of Samoa at 4:05 p.m., Eastern Standard Time.

Shepard reported by radio from the floating craft that he and his crew mates were in fine condition. Only one very minor hitch marred the otherwise ideal splashdown events. The parachutes were rigged to jettison the moment the craft touched the water so that a gust of wind could not accidentally cause the craft to be dragged. One chute's shroudline failed to release itself. It was cut by one of the frogmen who jumped from a low-flying helicopter to fit the spacecraft with its flotation collar and to provide a raft for the astronauts from which they were picked up by helicopters for transfer to the recovery vessel.

At Mission Control happy homecomings have become a tradition. Splashdown ceremonies which began spontaneously at Mission Control have, through the years, become a ritual performed with almost as much precision as a space mission.

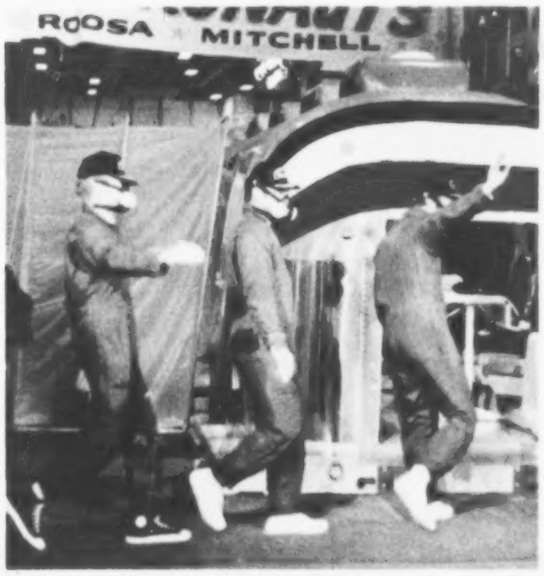
At the moment the large projection of the color television picture in the control room showed that the Apollo 14 astronauts were safely aboard the recovery ship, boxes of cigars were passed around in what has become a familiar scene at Mission Control. Beaming flight controllers and officials began blowing smoke rings.

Earlier, during key points of the recovery operations, applause broke out, almost as if on cue, in the control room and in the adjoining guest viewing-room from where visitors can see the control operations through glass panels.

All hands clapped heartily when the image of the returning Kitty Hawk was first picked up by the television cameras, when

Astronaut Roosa is lifted into the recovery helicopter.

Wearing masks to prevent possible contamination from the Moon, Apollo 14 astronauts walk from the helicopter to Mobile Quarantine Facility (MQF) aboard the recovery ship USS New Orleans.



the chutes flared open, and when the craft hit the water.

Even before the crucial re-entry maneuvers began, while flight controllers and officials were tensely watching the monitoring consoles and listening to the ground-to-space conversations with the astronauts, workmen quietly moved through the control room with a ladder. They raised it against the control room wall. At the moment of splashdown, a workman atop the ladder hung the Apollo 14 emblem on a hook that had been attached before the mission began, next to the emblems of the previous Apollo flights.

How well Mission Control was prepared for a safe return of Apollo 14 became even more apparent when the astronauts stepped from the recovery helicopter to the Mobile Quarantine Facility (MQF) in which they were to begin their return to Houston. The projection of the world map, which takes up most of the control room's front wall to show the location of the spacecraft during a mission, was turned off.

In its place appeared the projection of a four-color poster reading "Welcome Home, Kitty Hawk."

Through MQF window, Roosa, Shepard and Mitchell watch their welcoming ceremonies.

Major Events in the Apollo 14 Mission

Date (1971)	Time (EST)	GET* (hr.; min.)	Events
Jan. 31	4:03 p.m.	–	Weather-delayed but flawless launch.
	6:37 p.m.	2:34	Rocket ignition to leave Earth orbit and head for Moon.
Feb. 1	10:39 p.m.	30:36	Transfer maneuver for better initial loop of Moon. However, this precluded unpowered return to Earth.
Feb. 4	*2:00 a.m.	82:37	Rocket ignition to slow down Apollo 14 so that it would go into orbit around Moon.
	2:41 a.m.	83:18	Upper rocket stage of Saturn V strikes Moon. Moon vibrates for three hours after impact.
	6:14 a.m.	86:51	Rocket ignition to place perilune of Apollo 14 within 50,000 feet of Moon, the closest that a complete Apollo spaceship has ever come.
	11:51 p.m.	104:28	Separation of Kitty Hawk and Antares.
Feb. 5	4:05 a.m.	108:42	Antares landing rocket ignites.
	4:17 a.m.	108:54	Antares lands in Fra Mauro region of Moon – 3°40′ S. Lat. × 17°28′ W. Long.
	9:50 a.m.	114:27	Shepard egresses from Antares to be followed shortly by Mitchell. Among activities are gathering of geological specimens (rocks), setting up scientific instruments, setting up American flag, and placing and turning on TV cameras. EVA: 4:50.
Feb. 6	3:11 a.m.	131:48	Walk about three miles, collecting geological samples. Nearly reach the rim of Cone Crater. EVA: 4:35.
	1:49 p.m.	142:26	Antares rockets from Moon.
	3:35 p.m.	144:12	Kitty Hawk and Antares are docked. Mating was direct rather than Antares first going into lunar orbit as lunar modules did on prior Apollo missions.
	5:48 p.m.	146:25	Antares is set adrift.
	7:45 p.m.	148:22	Antares strikes Moon, as planned.
	8:39 p.m.	149:16	Kitty Hawk ignites rocket to break out of lunar orbit and head for home.
Feb. 9	4:05 p.m.	216:42	Kitty Hawk splashes down in Pacific Ocean south of Samoa.

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*At 54 hours and 57 minutes into the flight of Apollo 14, the ground elapsed time (GET) clock was moved ahead 40 minutes. Thus, the EST conversion of subsequent GET will be 40 minutes earlier than straight conversion of the GET. The actual EST times of the events are listed.

Landing Site Named for Monk

Fra Mauro, the landing site of Apollo 14, is named for a 15th century Italian monk and cartographer. A map that he drew in 1457 showed the geography of Africa and Asia more accurately than earlier maps and was considered the greatest expression of Renaissance mapmaking. He also drew Moon maps.

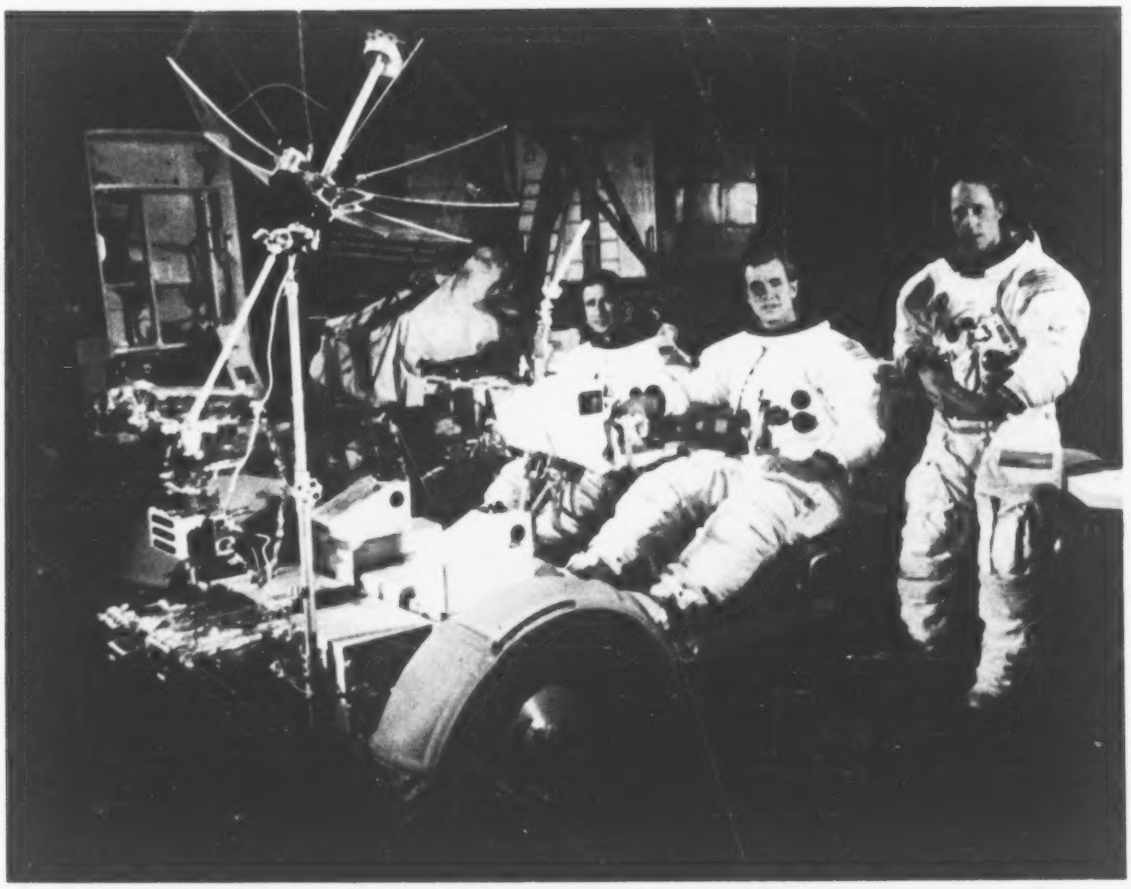
Origin of Spacecraft Names

The command spacecraft of Apollo 14 was called Kitty Hawk because as the astronauts put it: "That's where it all started." Kitty Hawk is a community in North Carolina where the American aviation pioneers, the Wright brothers, first demonstrated powered flight by man early in this century. The lunar module was named Antares for the star on which the landing craft oriented itself as it headed down to the Fra Mauro region of the Moon.

	Date	Flight Time (Hrs: Min: Sec)	Revolutions	Spacecraft Name	Remarks
Mercury					
Alan B. Shepard, Jr.	5/5/61	00:15:22	Sub-orbital	Freedom 7	America's first manned space flight.
Virgil I. Grissom	7/21/61	00:15:37	Sub-orbital	Liberty Bell 7	Evaluated spacecraft functions.
John H. Glenn, Jr.	2/20/62	04:55:23	3	Friendship 7	America's first manned orbital space flight.
M. Scott Carpenter	5/24/62	04:56:05	3	Aurora 7	Initiated research experiments to further future space efforts.
Walter M. Schirra, Jr.	10/3/62	09:13:11	6	Sigma 7	Developed techniques and procedures applicable to extended time in space.
L. Gordon Cooper, Jr.	5/15–16/63	34:19:49	22	Faith 7	Met the final objective of the Mercury program – spending one day in space.
Gemini					
Virgil I. Grissom John W. Young	3/23/65	04:52:31	3	Gemini 3	America's first two-man space flight.
James A. McDivitt Edward H. White, II	6/3–7/65	97:56:12	62	Gemini 4	First "walk in space" by an American astronaut. First extensive maneuver of spacecraft by pilot.
L. Gordon Cooper, Jr. Charles Conrad, Jr.	8/21–29/65	190:55:14	120	Gemini 5	Eight day flight proved man's capacity for sustained functioning in space environment.
Frank Borman James A. Lovell, Jr.	12/4–18/65	330:35:01	206	Gemini 7	World's longest manned orbital flight.
Walter M. Schirra, Jr. Thomas P. Stafford	12/15–16/65	25:51:24	16	Gemini 6A	World's first successful space rendezvous.
Neil A. Armstrong David R. Scott	3/16–17/66	10:41:26	6.5	Gemini 8	First docking of two vehicles in space.
Thomas P. Stafford Eugene A. Cernan	6/3–6/66	72:20:50	45	Gemini 9A	Three rendezvous of a spacecraft and a target vehicle. Extravehicular exercise – 2 hours 7 minutes.
John W. Young Michael Collins	7/18–21/66	70:46:39	43	Gemini 10	First use of target vehicle as source of propellant power after docking. New altitude record – 475 miles.
Charles Conrad, Jr. Richard F. Gordon, Jr.	9/12–15/66	71:17:08	44	Gemini 11	First rendezvous and docking in initial orbit. First multiple docking in space. First formation flight of two space vehicles joined by a tether. Highest manned orbit – apogee about 853 miles.
James A. Lovell, Jr. Edwin E. Aldrin, Jr.	11/11–15/66	94:34:31	59	Gemini 12	Astronaut walked and worked outside of orbiting spacecraft for more than 5½ hours – a record proving that a properly equipped and prepared man can function effectively outside of his space vehicle. First photograph of a solar eclipse from space.

	Date	Flight Time (Hrs: Min: Sec)	Revolutions	Spacecraft Name	Remarks
Apollo					
Walter H. Schirra Donn Eisele Walter Cunningham	10/11–22/68	260:8:45	163	Apollo 7	First manned Apollo flight demonstrated the spacecraft, crew and support elements. All performed as required.
Frank Borman James A. Lovell, Jr. William Anders	12/21–27/68	147:00:41	10 rev. of Moon	Apollo 8	History's first manned flight to the vicinity of another celestial body.
James A. McDivitt David R. Scott Russell L. Schweickart	3/3–13/69	241:00:53	151	Apollo 9	First all-up manned Apollo flight (with Saturn V and command, service, and lunar modules). First Apollo EVA. First docking of CSM with LM.
Thomas P. Stafford John W. Young Eugene A. Cernan	5/18–26/69	192:03:23	31 rev. of Moon	Apollo 10	Apollo LM descended to within 9 miles of Moon and later rejoined CSM. First rehearsal in lunar environment.
Neil A. Armstrong Michael Collins Edwin E. Aldrin, Jr.	7/16–24/69	195:18:35	30 rev. of Moon	Apollo 11	First landing of men on the Moon. Total stay time: 21 hrs., 36 min.
Charles Conrad, Jr. Richard F. Gordon, Jr. Alan L. Bean	11/14–24/69	244:36:25	45 rev. of Moon	Apollo 12	Second manned exploration of the Moon. Total stay time: 31 hrs. 31 min.
James A. Lovell, Jr. John L. Swigert, Jr. Fred W. Haise, Jr.	4/11–17/70	142:54:41	–	Apollo 13	Mission aborted because of service module oxygen tank failure.
Alan B. Shepard, Jr. Stuart A. Roosa Edgar D. Mitchell	1/31–2/9/71	216:01:59	34 rev. of Moon	Apollo 14	First manned landing in and exploration of lunar highlands. Total stay time: 33 hrs. 31 min.

Apollo 15 scheduled for July 1971



Apollo 15 Astronauts Irwin, Scott and Worden with Rover

When the Apollo 15 astronauts land on the Moon in July, 1971 Commander David R. Scott and his colleague, James B. Irwin, will bring to the lunar surface the battery-powered Rover, while the third crew member, Alfred M. Worden, waits for them in the command spacecraft in Moon orbit.

The astronauts will unfold the 450-pound (200-kilogram) conveyance—its full name is Lunar Roving Vehicle (LRV)—from its stowage compartment in the lower section of the landing craft and release the springs that will cause the Rover's components to snap into place. The Rover's range is 40 miles (65 kilometers), but the astronauts will remain within a radius of three miles (five kilometers) of their landing craft so that they could walk back to it if the Rover should become disabled on the rugged lunar surface. Even with that limitation, the astronauts will be able to ride over and explore an area equivalent to 28 square miles (73 square kilometers)—more than double the area astronauts can reasonably be expected to cover on foot in the allotted time. The LRV can attain top speed of eight miles (13 kilometers) an hour on a smooth surface, but on the dust and rock-strewn, crater-pocked Moon the astronauts may drive much slower. The Rover can carry up to 1,000 pounds (450 kilograms)—sufficient to transport the two astronauts in their Moon suits and related gear, plus large quantities of instruments, tools and Moon rocks.

Apollo 15's landing site is in the Hadley-Apennine region, a plain cut by a massive gorge along the base of some of the Moon's highest mountains. The site is 465 miles (748 kilometers) north of the Moon's equator, in contrast to the landing sites of Apollo 11, 12 and 14 which are all within 70 miles (115 kilometers) of the lunar equator.

The Rover's large, umbrella-like antenna transmits from the vehicle's television camera which will be used when the vehicle is parked. That TV camera can be controlled from Earth. In contrast to Apollo 14, when the astronauts walked out of range of their TV camera, viewers on Earth can continue to receive pictures of the Apollo 15 astronauts while they are some distance from their vehicle.

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